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Forthcoming Events.

MARCH 22.

Institute of British Foundrymen (East Midlands Branch):—Ordinary meeting at Loughborough.

Swansea Technical College Metallurgical Society:—General meeting at Swansea. "Some Experiments on the Annealing of Steel Sheets for Tinplate Making," Paper by J. C. Godsell.

MARCH 24.

Institution of Mechanical Engineers (Graduates' Section):—Informal discussion on "Failure of Metals."

MARCH 25.

Sheffield Metallurgical Association:—Ordinary meeting at Sheffield. "Notes on Hot Rolling," Paper by G. M. Brown.

MARCH 27.

Institute of British Foundrymen (West Riding of Yorkshire Branch):—Annual meeting at Bradford.

Institute of British Foundrymen (London Branch):—Ordinary meeting in London. "The Nature of Foundry Tools," Paper by J. Ferdinand Kayser.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institute of British Foundrymen.

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Propaganda of Foundry Requirements.

The majority of foundry technical Papers directly or through the discussions make an appeal for the co-operation of designers directly or through the patternmaker with the foundry. This question will in time resolve itself, but it is capable of acceleration by the presentation of Papers such as that prepared by Mr. P. Pritchard for the Institute of Automobile Engineers. This Paper is of special interest as it had for its object the presentation of the "foundry point of view." The Institute of Production Engineers last year had a Paper on "Machine Moulding Methods," by Mr T. Hardyman, who also utilised the occasion to further the simplification of design to facilitate moulding. Mr. Smalley has on two occasions before the North-East Coast Institution of Engineers and Shipbuilders and the Manchester Association of Engineers done similar propaganda, whilst Mr. Young has interested the Institute of Marine Engineers in the question. The work, however, is still disjointed and presented under diverse captions, and, possibly, with the exception of Mr. Pritchard's Paper, the question of co-operation has only been an incidental. Many clever Papers have been read before the Institute of British Foundrymen, and this session alone no less than three Papers by Mons. Ronceray, Mr. F. C. Edwards and Mr. H. M. Hodgart have been exclusively devoted to the subject. Additionally, an exceptionally strong plea was included in Mr. Harley's Paper on "Metallurgical Control in Automobile Practice."

We assume that it can now be taken for granted that foundrymen are unanimous in their desire for close co-operation and are seeking means for a consummation. Propaganda is an essential and as natural evolution has shown that the best method of carrying out this is by the presentation of foundry Papers by foundry experts to the great engineering societies.

This work is obviously one which falls to the Institute of British Foundrymen as the technical mouthpiece of the industry. We suggest that it should intimate to the various engineering societies that they are prepared to supply a lecturer, expert in the making of castings for the industry represented by the society, who would tell them *where they are wasting effort and money by their aloofness*. The engineering societies associated with the textile, building, public works, railway, gas, furnace building, civil, mechanical, electrical, mining, structural and metallurgical engineering industries and designers and draughtsmen's organisations all require instruction on "how to co-operate with the foundry."

If this can only be in part accomplished we anticipate that a greater confidence will be exhibited by engineers in cast metals generally and the gradual turnover to wrought material will be arrested.

Engineers have yet to appreciate that the thickening of a section in cast iron does not necessarily add to its strength. They do not yet understand that the breaking of a test piece only gives information about the metal in that test piece when cast under the conditions actually experienced by it. The changing of these and similar conditions is in the hands of the foundrymen They must, if necessary, "invite themselves" to lecture before engineering bodies.

XUM

Physical Tests for Cast Iron.*

By John Shaw (Sheffield), M.I.Brit.F.

Original Tests on Cast Iron.

Before an engineer can start work on the design of any piece of work he must have some idea of the strength and properties of the materials he proposes to use. For cast iron, various formulæ are given in text-books on the subject. These formulæ have been developed chiefly from data based on the loads obtained in the breaking of test-bars and castings. So far as this country is concerned, there is little doubt that the results of the experiments carried out by Sir Wm. Fairbairn and Hodgkinson from 1827 to 1837 form the basis of present-day formulæ for the strength of cast iron. It was about this time cast iron came into more general use in structural and engineering work. How little was known of its strength and properties was evidenced by the collapse of numerous mills and bridges. Fairbairn, amongst other data, suggested that 1-6th of the breaking load should be considered as the safe load for this material. As nine tons was the tensile asked for, a figure of 1½ tons per sq. in. was concluded to be the safe tensile strength of cast iron, a figure in fairly general use to-day. The designer having based his work on the above rule, naturally wishes to be assured that the material supplied complies with his estimated calculation; hence he imposes certain tests that he thinks will give the required information. How often these defeat the very object he strives for will be dealt with later.

That some test is necessary may be granted at once. Foundrymen all know of bars breaking at 7 tons, and where unsuitable metal is often used. Last week the author cast two 3-in. sq. bars, which were tested transversely at 3-ft. centres. One was cast from a No. 3 hematite, and the other from a close number of the same brand of iron. With each bar there was also cast three others, whose diameters conform to the sizes given in the I.B.F. draft specification. The results obtained by breaking these smaller bars will be dealt with later. The 3-in. sq. bar from the No. 3 hematite broke at 8.4 tons. The second, from the harder iron, broke at 9.5 tons. Yet the first iron was the dearer and under certain conditions the stronger, but for this thickness of casting would have been rejected as poor iron by many inspectors.

At this juncture attention should be called to a statement often made by some foundrymen. Why worry with tests? If there is any doubt about the strength of a casting, thicken it up; it is only so much bare iron that is being given away. These people forget that heavy sections, large fillets and strengthening ribs not only increase the cost of production and reduce the chance of making sound castings, but also weaken the structure as a whole. Increased weight means increased cost of foundations and other considerations. Increased weight in motor castings, for instance, is a vital point. The problem of design in such structures as the Forth Bridge resolves itself into one of carrying its own dead weight equally as much as allowance for wind pressure and the moving load—a point brought forcibly home by the collapse of the Quebec Bridge on two occasions before completion. Two points have now been established in the consideration of the subject:—(1) That before a machine can be designed there must be some strength data of the material to be used. Such data or formulæ have been built up from experimental work. (2) That the engineer requires some test applied to the material he uses so as to ensure it conforms to the standard mentioned in his formulæ. Coming now to the actual tests, everybody is agreed the best method would be to test the casting itself. That is not often possible, and where it is, often permanent set and deformation is set up, due to testing to twice or even three times the working load. Thus sometimes the casting is left in a weaker state than before testing. The testing to destruction of one casting out of a batch cast from the same ladle or metal only gives information about that one casting, and does not account for the hidden defects in any of the remainder due to causes other than metal. In short, it only proves that the particular casting was or was not sound, and that the metal was or was not suitable; the latter fact could just as well be found by a suitably designed test-bar.

While Fairbairn and Hodgkinson tested certain castings to destruction, it was more to arrive at the correct design than the mere strength of the material used. For this latter purpose, test-bars 1 in. sq. tested at 4 ft. 6 in. centres were used. While every credit must be given to the engineers of that and more recent times, there is no doubt their knowledge of cooling and mass action effect was very meagre, and it would appear from the tests for cast iron put forward that it is very little understood by their successors to-day. One has only to glance through the table of 51 British pig-irons, that took Fairbairn many years to compile, to realise this. He states:—"In the following abstract the transverse strength, which may be taken as *a criterion of the value of each iron, etc.*" Yet this value was obtained from irons where some were "hard," "soft," "soft and fluid," "rather hard," etc. No true comparison can be drawn from irons with such a variable structure. Three examples will explain this in Table I:—

TABLE I.—*An Abstract from the Work of Fairburn and Hodkinson.*

Brand	Breaking load 1 in. bar, 54 in. centres.	Deflection in inches.	Colour.	Quality.
Ponkey ..	567	1.75	Whitish grey	Hard
Butterley ..	489	1.01	Dark grey	Soft
Eglington ..	472	1.87	Dull grey	Rather Hard

The engineer has this consolation, that, judging from many of the weird proposals for mixing iron contained in the foundry literature of Fairbairn's time, the foundryman knew even less of metallurgy as we understand it to-day. How was it then that the foundryman complied with the tests specified. The chief reason was the fact that the blast furnaces were on cold blast, small, worked from picked local ores, with slow working. By these means a more regular and stronger product was made. It is common knowledge that to-day the cold blast irons of South Staffordshire commands just double the price of ordinary irons. For the above reasons the moderate tests asked for were obtained with a wide difference in composition. With the advent of hot blast iron, with its faster driving and much more variable fracture and composition, also the fact that tests were more frequently asked for, trouble began, and there is little doubt many test-bars were made from iron that never went into the castings. The engineer, to protect himself, then insisted on the test-bar being attached to the casting. This led to the length of the bar being shortened. The whole question, so far as the foundryman was concerned, was so to place the bar as to obtain the strongest structure. If the casting was a thin one, he knew the most suitable metal for this was too open for an 1½-in. dia. bar, so he placed the bar as near the box edge and as far from the casting as possible, so as to obtain the chilling effect of the cool box.

If the casting was a very thick one, the reverse procedure obtained, and the bar would be placed as near the heavy casting as possible to obtain the full annealing effect on the structure of the bar. The worst feature from the engineers' standpoint is the fact that the mixture is often hardened or softened, as the case may be, to get a compromise between the casting and the bar. By this means—the specifying of a size of bar utterly unsuited for the thickness of the casting—it is obvious that the engineer is directly responsible

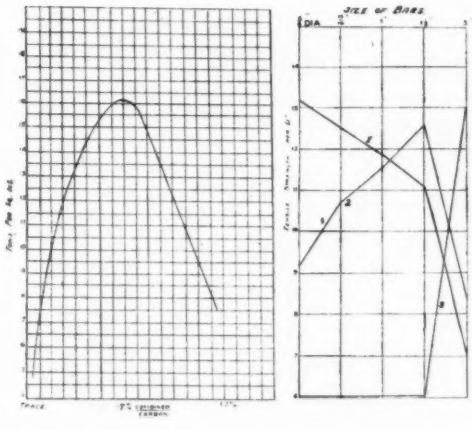
* A Paper read before the Coventry Branch, Mr. C. Dicken presiding.

for many poor strength castings. Where the bar and casting are about the same section, there is little trouble in obtaining present-day tests.

The question of design in relation to this problem of tests and strength of castings is as vital as any, and calls for that consultation between the foundryman and engineer so often advocated. Given a casting of fairly uniform section, it would be possible to reckon on a safe load of 2.5 tons per sq. in. That would mean scantlings could be reduced by 50 per cent., even if one retained any thinner sections in the same casting, so as to give a more even thickness throughout and therefore a more even cooling and a stronger casting, using the correct type of metal.

Mention has been made of the casting of two 3-in. sq. bars from metals of good variation, and gave the test results. It was also stated that the author cast three bars from each metal which conformed to the sizes given in the I.B.F. specification. The results of the tensile tests on these bars were as follows. From the hard metal the $\frac{7}{8}$-in. bar was quite white. The 1.2-in. bar was badly mottled. The 2.2-in. dia. bar was grey, and when turned to 1.785 in. dia. in the centre, broke at 12.3 tons. The three bars from the soft metal yielded the following results. The $\frac{7}{8}$-in. dia. bar turned down to 0.564 in. dia. in the centre, broke at 13.04 tons per sq. in. The 1.2-in. dia. bar, reduced to 0.798 in. in the centre, yielded 12.04 tons per sq. in. The 2.2-in. dia. bar, turned down to 1.785 in. dia., broke at 9.6 tons per sq. in.

Graph I outlines the results of work done by Prof. Turner, Cook and others, showing that the greatest strength of any given iron is obtained with the C.C. from 0.7 to 0.9 per cent. Mr. Gresty, of the North-Eastern Marine Engineering Company, recently informed the author that their results were round about 1 per cent. C.C. The publications and patents concerning the manufacture of "Pearlitic cast iron" is another confirmation of the above statement.



Graph II gives the results of a series of experiments made on various sizes of bars, each set cast from a metal suited to various work. The bars were $\frac{7}{8}$ in., 13-16 in., 1 in., $1\frac{1}{2}$ in. and 3 in. dia. Each set of five bars was cast in one box from the same ladle. No. 1 iron was used for thin strong castings. The $\frac{7}{8}$-in. bar yielded 13.25 tons per sq. in., and then, as the sizes of the bar increased, thus giving a more open structure, the tensile strength dropped till only 7 tons was registered on the 3-in. bar. Iron No. 2 was used in steam cylinders 1.5 in. thick. This iron was too hard for the $\frac{7}{8}$-in. dia. bar, and only 9.5 tons per sq. in. was registered. There was a gradual rise till, at $1\frac{1}{2}$-in. dia. bar, 12.5 tons was obtained, with a drop to about 8.25 tons per sq. in. on the 3-in. dia. bar It should be noted that both these irons would have met the ordinary test of 9 tons tensile. The last iron was used in some hydraulic cylinders. Every bar up to the $1\frac{1}{2}$-in. dia. was white, and therefore no tensile could be taken. The 3-in. bar was grey, and registered over 13 tons per sq. in. at the Sheffield Testing Works. It should be particularly noted, in view of the results shown in Graph 1, that the total carbon in this third iron was 3.2 per cent. The C.C. in the 1-in. dia. bar was 3 per cent., while in the 3-in. dia. bar it was only 0.9 per cent. This is clear evidence that the bar must bear some relation in size to the thickness of casting it is supposed to represent.

Where the thickness of metal varies to a great extent in the same casting—a ship's propeller is a type—no test-bar will represent all parts of this casting, just as no metal will give maximum strength in all parts. The best must be a compromise in both cases. The foundry manager has to make up his mind before charging for this casting what type of metal he will aim for, whether it shall be suitable for a casting 2 in. or 3 in. thick. Once this is done, he knows what diameter of test-bar to use, and the test result will give him some idea if he has attained his object.

Present Day Specifications.

Crown Agents.—Cast iron is to be made from best pig-iron, and must be close-grained, hard, tough and perfectly free from all defects or blemishes. The cast-iron test-pieces must be cast with the broader side of the bar uppermost. Bars for making these tests must be cast and tested before the commencement of the contract, and at such intervals subsequently as the Inspector shall direct. The cast iron to be of such a quality that a bar of the same, 1 in. broad and 2 in. deep, placed on edge on bearings 3 ft. apart, shall not break with a less load than 30 cwts. suspended in the centre, nor with a deflection of less than 0.3 in. Yet to this specification castings that do not exceed $\frac{3}{8}$ in. thick are asked for, and at the other extreme castings with no section less than $2\frac{1}{2}$ in. thick.

Admiralty.—The Admiralty specification presents the same anomaly. It reads that test-pieces are to be taken from such castings as may be considered necessary by the Inspector. A bar 1 in. sq., tested on supports 12 in. apart, shall bear a load of 21 cwts. without breaking. The minimum tensile shall be 11 tons per sq. in. taken on a length of not less than 2 in. The general practice for the latter is to cast a bar $1\frac{1}{4}$ in. dia. and to turn this down to 0.798 in. for 2 in. in the centre. Here, again, this specification has been used for small cylinders $\frac{3}{8}$ in. thick, and at the other extreme fly-wheels with a rim thickness of 12 in. Some little time ago the author was asked to make some chilled rolls for the Admiralty. The chill asked for was 1 in. deep. Now it is quite impossible to cast any bars below 3 in. dia with the composition needed to obtain 1 in. chill without the bars being white. Mr. Buckland, the Inspector, proved this for himself, and the down runner from the roll was broken off, turned down to 1.785 in. in the centre, and broke at over 13 tons per sq. in.

Many engineers seem to think that cast iron is a homogeneous material, and that a specification issued by the B.E.S.A. covers every casting on earth. Recently there was an inquiry for some compressor heads with a minimum thickness of $5\frac{1}{2}$ in. The iron was to comply with the B.E.S.A. tests for pipes.

New Railway Specification.

In October last the L. & N.E. Railway issued a specification for iron castings. They specify a bar 2.25 in. × 1.25 in. × 28 in. long, to be cast near the top of the cylinder attached to the flange. The transverse tensile and compression test-pieces are to be cut from this bar. No serious objection can be taken to this bar so far as the cylinders are concerned; the two sections bear some relation to each other. A round bar would have been preferable. Also, care will have to be taken in centring for the tensile; otherwise the structure will vary greatly and there will be a weak side. Even if the bar is centred truly, it will be necessary to remove approximately $\frac{3}{4}$ in. aside from the 2.25 in. wide bars, while a bar 6.25 in. will be all that requires turning off to arrive at a diameter of 0.798 in. in the centre. When this bar is specified for general castings, grave objection will be taken to its application to thin or thick castings. If axle boxes now average about $\frac{3}{8}$ in. thick, then to get the best test on the size bar asked for will render the pin lugs on the grease box commercially undrillable.

(To be continued.)

XUM

Institute of British Foundrymen.

Fund for Annual Convention in Newcastle.

In our issue of March 6 we published a list of subscriptions which had been received or promised for the £500 Newcastle Convention Fund. It then amounted to £307. Since that time another £100 has been received. The committee, whilst being satisfied at the response shown, are not relaxing their efforts, and feel confident that before the end of the month the £500 mark aimed for will be exceeded. It will be noted that the response has been national; we hope that this universal interest will be maintained.

	£	s.	d.
Previously acknowledged	307	11	0
Messrs. Palmers Shipbuilding and Iron Company, Limited	25	0	0
Messrs. C. A. Parsons & Company, Limited, Heaton	20	0	0
Messrs. Mann, Judd, Gordon & Company, Glasgow	10	10	0
"Moulders and Core-makers," the North-Eastern Marine Engineering Company's Wallsend Foundry	6	7	0
Messrs. Noble & Lund, Limited	5	5	0
J. W. Jackman & Company, Limited, Manchester	5	5	0
Mr. Victor Stobie	5	5	0
Mr. H. A. J. Rang	5	5	0
Mr. G. F. Tweedy	5	5	0
Messrs. James Hogg & Sons, Limited	2	2	0
Messrs. Dunford Brothers	2	2	0
Messrs. F. Turnbull & Company	2	2	0
Mesars. Nicholson Tool Company	2	2	0
Messrs. Balls & Stansfield	2	2	0
Messrs. William Cumming & Company, Glasgow	2	2	0
Messrs. Brady & Martin, Limited	2	2	0
Mr. A. Thomson	2	2	0
Engineer-Commander C. J. Hawkes, R.N.	1	1	0
Messrs. Vaughan & Dymond, Limited	1	1	0
Mr. J. K. Arrowsmith	1	1	0
Total	£415	12	0

The Hon. Treasurer, Mr. H. F. Parsons, 8, Heaton Park View, Heaton, will be pleased to receive further subscriptions, which will be acknowledged through the Press.

Annual Convention to be held in Newcastle.

This year the Annual Convention will be held in Newcastle on June 4, 5 and 6. A local Reception Committee has been appointed, which is composed of the following members:—

Mr. E. Wood (chairman), Mr. H. J. Young (vice-chairman), Mr. H. F. Parsons (hon. treasurer), Mr. C. Gresty (hon. secretary), Messrs. James Smith, R. O. Patterson, J. W. Frier, M. B. Herbst, H. A. J. Rang, F. Adam, J. A. Campbell, M. E. Gallon, W. Mathews, T. McPherson, W. J. Paulin, F. Sanderson, E. Smith, R. H. Smith, V. Stobie, A. H. Tait, G. Vardy, J. M. Weir, H. C. Jay (representing the Junior Section) and Miss M. D. Pittuck.

The committee is already busy preparing for this Convention, and a full programme is being drawn up. A letter of appeal for support has been widely circulated in the district, and it is hoped that everyone will try to "do his bit" to make the Convention a real success.

SOUTH WALES AND MONMOUTH BRANCH.

At a meeting held on March 15, the following officers were elected:—Branch-President, Mr. P. Leonard Gould, Vulcan Foundry, Cardiff; Senior Vice-President, Mr. F. Taylor, Briton Ferry; Junior Vice-President, Mr. B. Hird, Cwmbran; Hon. Secretary, Mr. J. J. McClelland, M.I.Mech.E., of Whitchurch. Messrs. J. P. Galletly (Cardiff), W. E. Clements, J.P. (Llanelly), and S. J. C. Padfield (Newport) were elected to serve on the Council for three years; Messrs. W. C. Gould (Barry Dock), A. D. Haines, B.Sc. (Whitchurch), and W. S. Kinsman (Cardiff) for two years; and Messrs. O. R. Gibbon (Newport), W. Morgan (Porth), and R. G. Williams (Barry) for one year. Mr. P. Leonard Gould and Mr. J. J. McClelland were elected as representatives to the General Council.

A very lively interest was taken in the proceedings, and the Branch was undoubtedly started under very promising circumstances.

Iron and Steel Production in February.

The production of pig-iron in February amounted to 612,700 tons, compared with 636,600 tons in January and 543,400 tons in February, 1923.

The number of furnaces in blast at the end of February was 202, compared with 190 at the end of January and 204 at the beginning of the year: the net gain since the end of January is therefore hardly equal to the number that were damped down owing to the railway strike.

The production includes 196,400 tons of hematite, 215,800 tons of basic, 137,800 tons of foundry, and 33,200 tons of forge pig-iron.

The output of steel ingots and castings in February amounted to 767,600 tons, compared with 694,300 tons in January and 707,100 tons in February, 1923.

Foundry Queries.

Locomotive Cylinder Mixtures.

We have for some years read your journal with considerable interest and benefit, and should be obliged for information regarding cylinder mixtures for locomotive cylinders. It is our invariable practice to make such castings of approved pig-irons. Experiments have been recently carried out with a cylinder mixture containing a percentage of steel scrap of boiler plate quality, and we are informed that the results have been satisfactory. We are advised that certain railway companies will not accept cylinder castings which have been made from a mixture containing steel, and therefore we are seeking information as to the effect of steel on such castings.

The tests for the castings under consideration should be:—

(1) 30-33 cwts. transverse breaking load on a test bar 2 in. × 1 in. section supported on 3-ft. centres.

(2) 12 tons per sq. in. in tensile strength.—CYLINDERS.

Core Ramming Machines.

We shall be glad to learn if there is any machine suitable for ramming cores for dry batteries. They are of various dimensions, the largest of which is 3¾ in. high × 1¾ in. dia., having a carbon rod in the centre 15 mm. dia. The smallest size is 1½ in. high × 15 mm. dia., with carbon rod in the centre 6 mm. dia.

J. W. & C. J. P., LIMITED.

Patent Specifications.

Particulars of Complete Specifications Accepted, furnished by Mr. Eric Potter, Patent Agent, of 27, Chancery Lane, London, W.C.2. Printed copies of the specifications in the following list are now on sale.

MARKS, E. C. R. Electric furnaces melting of manganese steel scrap. 212,121.

METROPOLITAN VICKERS ELECTRICAL COMPANY, LIMITED. Electric furnaces. 212,190 and 212,191.

THE ARTIC FUSE AND ELECTRICAL MANUFACTURING COMPANY have removed to Elizabeth Avenue, Elizabethville, Birtley.

THE VICTORIA WAGON WORKS, LIMITED, Bristol, have acquired the goodwill and stock of the agricultural department of the Bristol Wagon & Carriage Works Company, Limited, carried on at 138, Victoria Street, Bristol, and Lawrence Hill, Bristol.

THE JANUARY-FEBRUARY ASCERTAINMENT under the sliding scale in force in the North-West of England shows that the average selling price of Bessemer mixed numbers of hematite pig-iron was £5 1s. 6d. per ton, an increase of 1s. 8d. per ton. Blast-furnacemen's wages accordingly rise by 2 per cent. to 39¼ per cent. above standard. The percentage on bonus earnings in the Workington district is now 76¾ per cent. and in the Furness area 71¾ per cent.

A Pattern Shop Talk.*

By G. E. Dicks.

In speaking of the pattern shop it is almost necessary to refer to the drawing office and foundry also. These three departments, where patterns are concerned, should be closely allied, and work together to find the best way to increase output and produce the best castings.

The designer of any particular machine, after preparing his rough outline and details, should confer with the heads of the foundry and pattern shop before finishing the drawing. Their advice at times eliminates much unnecessary pattern-making and simplifies the work in the foundry, the moulder and patternmaker can work out their own salvation: this, as a rule, is an easy matter. From personal experience the foundry will always co-operate to attain the best possible productive results.

The draughtsman is not in so close touch with the foundry as the patternmaker, and however good he might be in his own line, it is the moulder who has to produce the castings required. Numerous difficulties can be overcome without any loss of dignity on either side by consultation.

All patternmakers should have a technical knowledge of machine drawing and construction, together with some practical training in foundry work. If their ideas of the future do not carry them beyond being a patternmaker all their lives, they should at least have self-respect enough to try to be a first-class patternmaker. It is hoped the present time apathy is only a passing phase, that the younger men will value the many advantages gained by knowledge, and make every possible sacrifice to collect it. They will find later that in one thing alone they will be amply repaid, and that is in having the pleasure and satisfaction of being "on the top of their job."

The foreman and employer have, of course, their responsibilities also towards these young men, the foreman in not only explaining how to do the work, but also giving a reason why it should be done in any particular way. A pattern shop foreman always has plenty to do, and his main job is to get out the work; but still, he should remember that a little extra time spent on his younger hands will be well repaid later, both to himself and his employer.

In one recent case a youth was given a job, which, under ordinary circumstances, a man would have done; with a little supervision it was completed to everyone's satisfaction.

All patternmakers should not only be able to read blue prints quickly, but should have a clear vision of the finished job before starting on the work; a few hours spent in thoroughly grasping all details will save much later worry and anxiety This, of course, refers to larger work that may take three to four weeks to complete.

Selection of Timber.

A judicious selection of timber for various kinds of jobs is necessary; quite common pine, or even spruce, is good enough for many jobs, but in every case it should be well seasoned. Usually for large and medium size patterns pine is used; if the timber is properly seasoned it is the best and safest wood for pattern work. For small standard patterns mahogany has long held first place; it is light, easily worked and gives a good, smooth surface when finished. Unfortunately its use is somewhat restricted by its cost, but it is the ideal wood for patterns that require skilful handiwork. Quite a number of the harder woods from time to time have been tried, such as apple, cherry, whitewood, and birch, but in each case there is a tendency to warp, although a good finish can be obtained. The nearest approach to mahogany is cedar, which is easily worked, but of a much softer nature than mahogany.

Built-up Jobs.

In built-up jobs more consideration should be given by the men themselves to the thickness of the wood, and to the number of battens necessary, as it will often be found that internal strengthening ribs are twice the thickness required, making the job much more expensive and heavier to handle. Glue should be used sparingly in the pattern shop and with discretion. For segment work it is essential, but where there is a possibility of any alteration in the future to a pattern it should be avoided. A thin coating of shellac varnish will make a good joint, with the advantage that on parting the joints will not tear the wood very much. This allows for any alteration that may be required to the pattern. Too many nails are often used, making any future alteration somewhat expensive. It is far better to use screws wherever possible. Screws, though less economical than nails, make a much sounder job, and can easily be removed when alterations have to be made.

It would seem unnecessary to refer to the filleting of corners; patternmakers are so much aware of the necessity of this, but do they put their knowledge to actual use? In many cases the fillets are left out no doubt for the moulder to pare, and for him to make them any size he cares to. Reference is not made only to simple fillets in corners, but also to special pipes, tee pieces, etc. The corners may be filleted upon the pattern, but the cores, being struck upon a plate, are butted together and the corners left sharp. Fig. 1 shows a tee piece, angle and fillet-rubber treated in this manner.

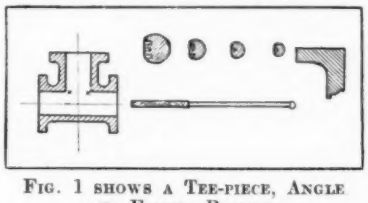


FIG. 1 SHOWS A TEE-PIECE, ANGLE AND FILLET RUBBER.

Even with the ordinary fillets at a corner placed there by a patternmaker, they are often either too small or flat. A fillet should in most cases incline more to the thinner section, as is shown in Fig. 1. A very useful fillet rubber is also shown; it has a handle screwed at the bottom to take various cups, to suit different radii; this is for leather fillets from $\frac{1}{2}$ to $\frac{3}{4}$ in.

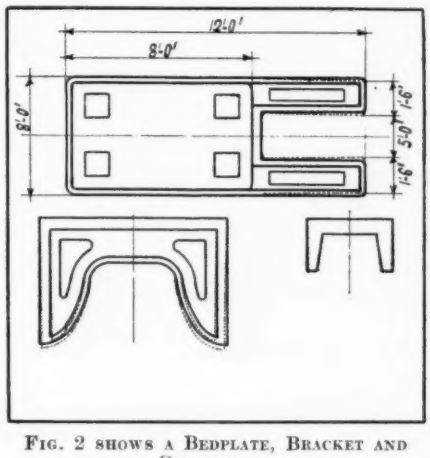


FIG. 2 SHOWS A BEDPLATE, BRACKET AND CHANNEL.

Taper.

Taper is often a sore subject between pattern shop and foundry, and on this one point alone, both with patterns and core prints, a good patternmaker with judgment is an asset, and he may be expected to give a correct angle between the 45 deg. the foundry asks for and the 90 deg. usually given.

* A Paper presented to the Birmingham Branch of the Institute of British Foundrymen.

Splitting Patterns.

The splitting of patterns is another debatable point. The ideal pattern is, of course, the one that is split right along the parting line, no matter how irregular that may be. This is seldom possible, but a patternmaker should remember that this is the ideal, and it is something between that and the solid pattern which is correct, taking into consideration the design, number off, etc.

Contraction.

Contraction is another subject when the patternmaker of judgment comes into his own. How often do we hear, "But I worked to the contraction rule," in a tone that implies it is the beginning and end of all things. Even a plain plate, say 1 in. thick, where everyone would agree (if discussed at all) that the thickness would gain, is made to the contraction rule, when the pattern should be at least 1-32 in. undersize.

When castings are made from pattern plates and these have in turn been made from ironmasters, the necessity of judgment is even more essential; and for many castings, such as stove, grate and electrical work, say 3-16 in. thick, the masters, if made from rolled plate metal, should be 1-32 in. less to allow for the gain that takes place.

In dealing with larger castings the size and shape must be considered in making contraction allowances, and the following illustrations will, no doubt, be interesting.

The top diagram of Fig. 2 shows a large bed plate, approximately 12 ft. long, the main square portion being 8 ft. × 8 ft., with long projecting arms on each side extending out 4 ft., these arms being 1 ft. 6 in. wide. Patternmakers would allow the ordinary contraction, say, 1-10 in. per ft. on the main portion, 8 ft. square, but between the arms at the extreme end there is 5 ft. of sand. This dimension should be made to the standard rule, and gradually die back into the main body of the pattern. At these points there is no metal to contract, and in the cooling of the casting the tendency is to force the arms outwards.

In the case of a large double bracket, where the irregular internal rib and beading are of a similar section to the sides, one would expect the full contraction to take place along the straight portion at the top of the bracket, but where the ribs join the sides at the bottom the irregular shape causes partial contraction, and it will be found advisable to allow only half the usual contraction on this dimension.

With the channel shown in Fig. 2 a similar action takes place, and should the flanges be very deep there would probably be no contraction at all. In fact, the cooling of the metal in this case might have a tendency for the flanges to incline outwards.

For some years the author was engaged with a well-known firm of lighthouse engineers, the only firm that manufacture the complete structure from the base to the weathervane, with the exception of any masonry work; this, of course, being a

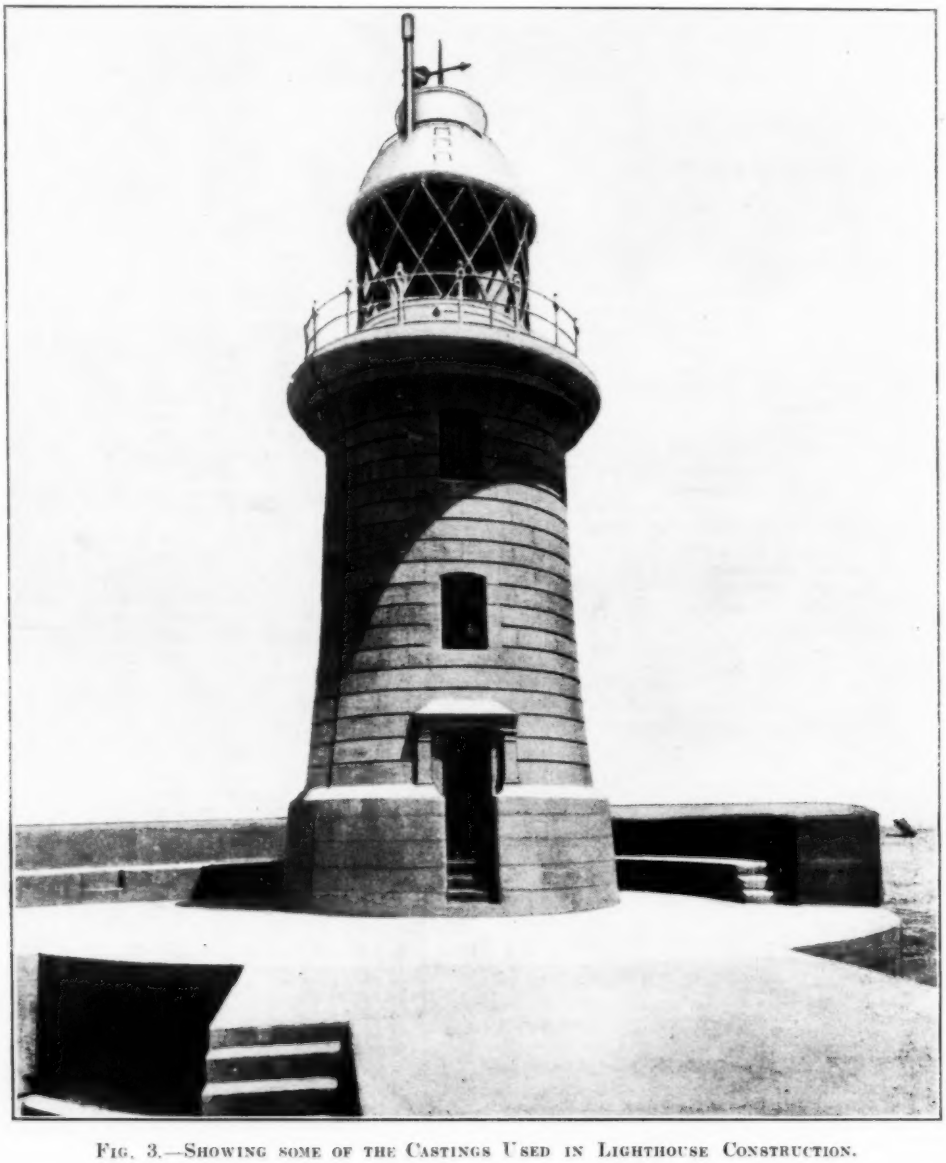


Fig. 3.—Showing some of the Castings Used in Lighthouse Construction.

separate branch of engineering. The towers of lighthouses are constructed principally of cast iron. From a patternmaking point of view, this kind of work is very interesting. It is proposed to illustrate some methods of the construction and marking out some of the principal patterns, such as the diamond frame, top carriage, and the peculiar shape racks.

The diamond frame shown in Fig. 3 forms the outside framework of the lantern, and is fitted with plain glass. This acts as a protection chamber for the optical apparatus.

The helical framework (Fig. 4) is constructed in sections, the number varying according to the diameter of lantern. It is, of course, only necessary to make one section for the pattern. This is built up on a ramming board A. The outside diameter of the frame radius B, is struck to standard rule. The outline of the pattern is then marked out on

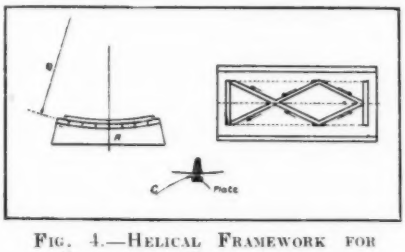


Fig. 4.—Helical Framework for Lighthouse Construction.

the board, also to standard rule, along the strips in the directions shown by the arrow marks, the contraction being added. The outline is again marked to the new points found, this gives the shape and correct length for the pattern.

The pattern being in strips and fragile, is made of mahogany in short lengths, dovetailed in one another, each part being dowelled in position on the block before cutting to shape; this portion of the pattern is finished, and forms the part that is in the drag.

The strips C, which run the whole length of the pattern, are also made loose and in short lengths, fitted with sockets that match the corresponding dowels in the frame. The strips C are placed in position on the pattern after the drag is rammed and the block removed. The section of the frame

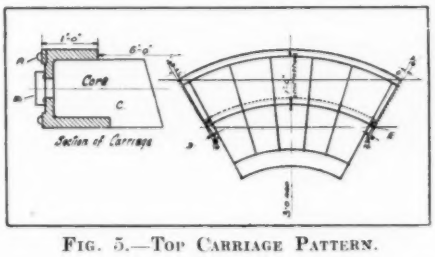


Fig. 5.—Top Carriage Pattern.

follows the radius, and, looking along the strips has an elongated screw formation; this is the reason the frame is made in parts, so that each can be drawn separately from the mould. As the full contraction only takes place along the length of the strips, the horizontal one forming the top rim has to be set slightly inwards, as the frame is only connected in the centre.

A recent invention consists of an arrangement called the light valve for unattended lights. This has recently been patented by Messrs. Chance Brothers & Company, Limited. It is affected by the daylight, and at present used for acetylene lights. It operates a valve which shuts off the gas in daytime and allows the gas to pass freely at night, a small bypass, of course, continually burning. This action is caused by two small glass bulbs connected, each being half-filled with ether; one of the bulbs has a coat of black, the other clear. The light's rays on the black bulb causes heat, which raises the ether, forcing it into the clear bulb. This overbalances the lever, so shutting off the gas, and at night the reverse action takes place, and allows the gas to pass free to be again ignited by the small bypass flame.

Top Carriage.

With the top carriages (Fig. 5) these are made up of four, six or eight segment castings, according to the diameter of light required. This pattern is built up with two rows of segments, one at the front and one to form the taper of the print. The top and bottom plates are let in, these being sectional pieces of wood radiating to the centre, thus adding to the rigidity and preventing any warping likely to take place. The beading A is made loose in two or three parts, to be drawn in after the main body pattern is removed from the mould. The cores B are for inspection holes; these holes have a small beading round. These cores are placed in position before the main core C. If the carriage is of a light type design and not very deep the whole front panel of the pattern, in two or more parts, is made loose and drawn afterwards.

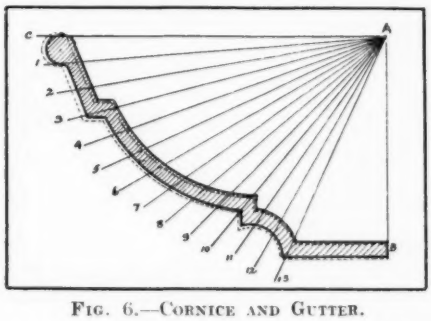


Fig. 6.—Cornice and Gutter.

In this case the cores B will not be required. In setting out after the segment is built up in its rough state and planed to the proper depth, taking the example before us, the outside diameter being 8 ft. and the inside 6 ft., the 3-ft. radius of the inner circle is struck to standard rule, the width of the segment, 1 ft., is marked off by contraction rule, setting the trammels and maintaining the same centre the curve is drawn, then on the inner circle to the standard rule points D and E are found, equally on each side of the centre line. From these points radiating lines are drawn, cutting the outer circle at F and G. Next a cord line is drawn through points D and E. And the contraction is added on this cord on each side, and parallel lines are drawn to the radiating lines. This gives the contraction on the length of the pattern. From personal experience of patterns of this or similar designs, very little perceivable alteration of the curves takes place; if anything, the outer diameter of the segment has a tendency at the extreme points to open out, and this method of setting out gave the best result.

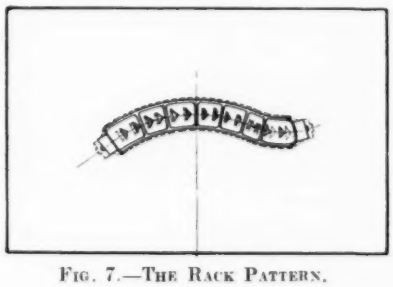


Fig. 7.—The Rack Pattern.

Cornice and Gutter.

With the cornices and gutters of the lantern there is a very irregular section to deal with, being in most cases of an ornamental design. The pattern is made in hardwood on a ramming block. The reason for this is that lighthouses are of various designs, and very seldom can the pattern be utilised again. If required for repetition work, of course, the pattern would be made of iron. Work similar to this requires care in adding the necessary contraction. Fig. 6 shows an ornamental gutter. This was set out from the drawing exactly full size to the standard rule, the vertical line A, B is drawn, and the line A C at right angles to it. A series of points, 1, 2, 3, 4, etc., are marked on the main features of the section, and lines are

drawn radiating to the point A. These lines are measured with the standard rule and the contraction added. It will be noticed the dotted line gives the exact outline for the pattern. If this method be adopted for adding contraction to irregular work of this description many anxieties will be overcome in the pattern shop.

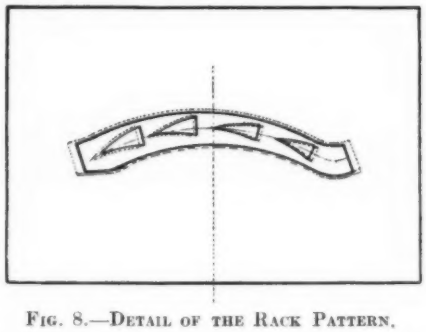


Fig. 8.—Detail of the Rack Pattern.

First order quadruple flashing, light flash equal to 400,000 candles, gives four flashes in quick succession every 15 seconds.

The weight of the lenses, with table, etc., revolving in the bath of mercury is 4 tons.

Racks.

The gunmetal racks of the flashing apparatus carry and support the refractor and reflecting prisms, some of which run vertically through the light, and others at different angles; the latter are termed projection racks. In many cases there are twenty prism-shape holes. The patternmaker works from a tracing, which gives the outline and position of the holes when cast (Fig. 7), an allowance of 2mm. all round for fixing the glass prisms in plaster is given. Some racks are solid, and

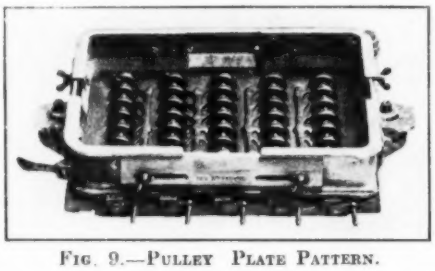


Fig. 9.—Pulley Plate Pattern.

others are lightened out. Dealing with the latter, these are generally right- and left-handed, so they can be made in pairs. The backs are approximately 3-32 in. thick, strengthened up to ⅜ in. by means of ribs around the rim and bars between alternative holes. The contraction of these racks has given considerable trouble on occasion, but it was successfully overcome by the following method of setting out.

With a pair of racks the backs are planed to the 3-32 in. thick, and tacked together by small panel pins. The tracing is placed on top; the outline is pricked through. On removing the tracing the

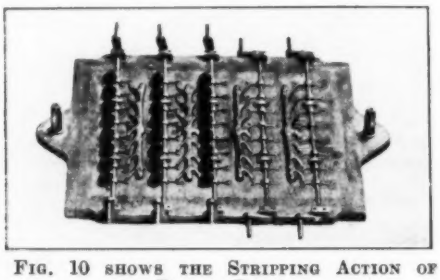


Fig. 10 shows the Stripping Action of the Pulley Pattern.

outline is drawn with pencil, and through the centre of the rack a line is drawn, striking each centre point of the holes. This is the construction line, on which is added the contraction, working from the centre of the rack, first to the right and then to the left. The points now found give the position to mark the holes on the pattern. These holes are cut square through, taper being cut after separation. The strengthening ribs around the rim and bars are added on reverse sides of the plates, thus making them right- and left-handed (Fig. 8).

Speaking on contraction, it is to be clearly understood that it is not the author's intention to enunciate any fixed methods of setting out work. Many points must be taken into consideration by the patternmaker.

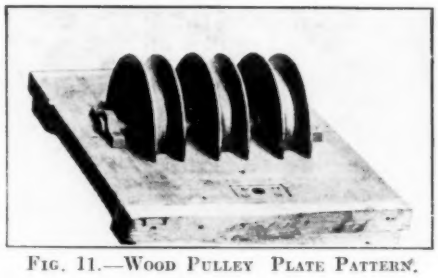


Fig. 11.—Wood Pulley Plate Pattern.

Metal Patternmaking.

Metal patternmaking is not a distinct trade—practically the same knowledge is required as in wood patternmaking. Pattern plates have been in existence for a long time, but have increased during recent years owing to the demand for castings of a repetition character. Many advantages are gained by metal over wood; the metal does not warp, neither are the dimensions seriously

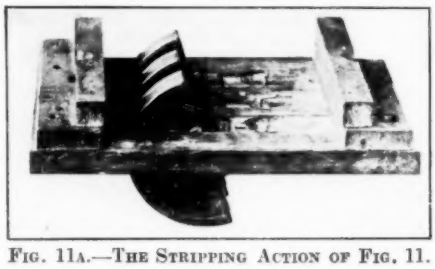


Fig. 11a.—The Stripping Action of Fig. 11.

affected by the atmospheric conditions, and with care, endless number of castings can be made from plates. With pattern-plates, the joints and runners are already formed, thus saving the operation in the foundry. If it is decided to have a pattern plate it is essential that the workmanship should be of the best. The design governs the class of plate to construct, either an all-cast,

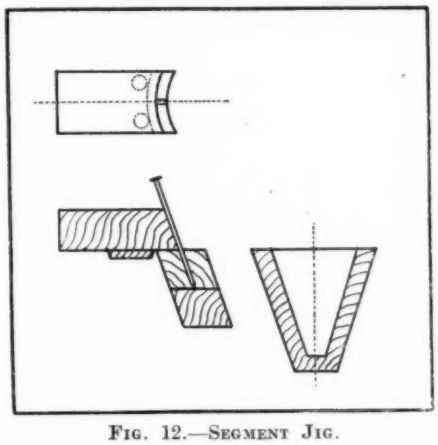


Fig. 12.—Segment Jig.

reversible, plain, turnover, or stripping plate. Where a plate is used on a moulding machine it is advisable to be at least ⅝ in. thick, and if a wood plate is used, which is sometimes the case, the plate should be 1¼ in. thick; this should be the minimum to prevent springing when being rammed. All plates need attention after using, and should be thoroughly cleaned and dried before placing in the stores. Some standard should be

observed between pattern plates and moulding boxes to suit the general requirements of the particular foundry, but this should not interfere if output is to be maintained. Although pattern plates are not by any means a new method for production, there is certainly great room for extension in this country if we are to meet the foreign competition. Money spent on the installation of plant, such as moulding machines, pattern plates and suitable boxes, will not be regretted, if the ultimate result is the regaining of a large proportion of the world's trade.

Pulley Plate.

Two pattern plates recently completed by the author's firm no doubt will be interesting, although nothing is claimed as novel in their construction; both are pulley pattern plates. The first (Fig. 9) is a small sash pulley, 1¾ in. dia. by ½ in. wide, and on this plate are 40 half-patterns. The plate can be termed a combined stripping and

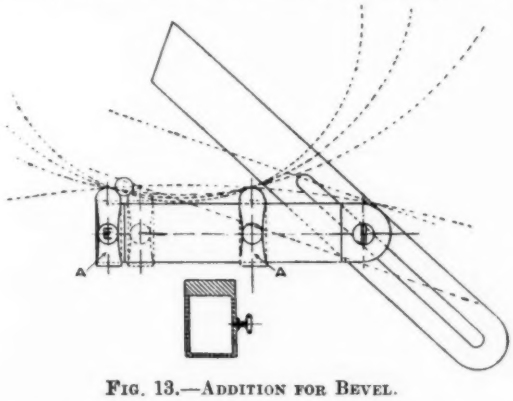


FIG. 13.—ADDITION FOR BEVEL.

pattern plate. Each row of the gun-metal patterns revolves on a spindle running the width of the plate in a half-round groove. On each end there is a lever to revolve the patterns out of the mould after ramming. The spindles act as core-prints, being the diameter of the holes required; around each half-pattern the usual white-metal joint is run, holes being cast with a dovetailed

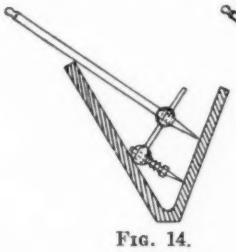


FIG. 14.

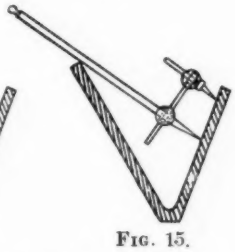


FIG. 15.

slot in the plates. This holds the metal securely in position. Tops and drags are rammed from the same plate, reversing the top when closing on. Fig. 10 shows the stripping action.

Wood Pulley Plate.

Fig. 11 shows an 8-in. pulley plate. It is made on similar lines to the smaller pulley, but in this case both patterns and plate are of wood, the plate being 1¼ in. thick, which should be the minimum. The same method of moulding is adopted, both top and drags being rammed off the same side of the plate. The only difference is that instead of levers to draw the patterns a steel handle is attached to the centre half-pattern at the back. By this handle the moulder slightly revolves the patterns, then completing the draw by handling the patterns. The spindle is the size of the cores and form the core prints. The number of boxes laid down per day of the small pulleys average 60 and of the larger pulley 30. A snap flask is used for the 1¾ in., and an iron moulding-box for the 8-in. dia. Fig. 11A shows the method of stripping.

A useful pattern-shop idea is a jig used in the rapid construction and building-up of tapered patterns, such as bell valves, etc. (Fig. 12). This jig is made of hardwood, cut to the angle of the pattern. Two small bosses at the back form the guide, the front edge being to the centre of the segment. A small groove is cut the same diameter or shape of the nail in the plate. The nail is inserted and driven in half way. The jig is removed, and the nail finally driven home. Where there is a number of rows of segments to be built up the jig gives the correct angle for nailing, and the patternmaker need not fear when turning his job of running into nails.

A Bevel Arrangement.

Another useful arrangement is an addition to a bevel. When the two clips A, shown in Fig. 13, are added to an ordinary bevel, a simple yet effective arrangement is obtained for getting angles on circular work from a small circle to the straight line. The illustration shows a few circles drawn, a clip being detailed in section. It has been found beneficial on all kinds of circular work, such as tanks, towers, etc. It will also be noticed that the clips can

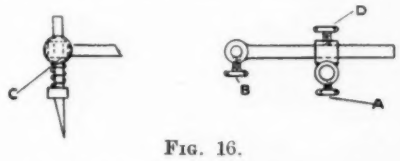


FIG. 16.

be used on internal work. They work on the shank of the bevel; slides, like a pair of trammels being fixed in any position by the small screws E.

Spring Compasses.

Another serviceable tool is the single shaft spring compasses; most patternmakers, no doubt on several occasions, have had to strike circles or semi-circles in acute angles or on work where it has been impossible to use an ordinary pair of spring dividers or compasses. With the instrument shown in Figs. 14 to 17 one is enabled to get circles on square work or circular work. The plan (Fig. 16) shows that the small shaft can be placed in any position on the main shaft by

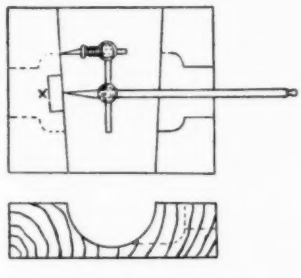


FIG. 17.

adjusting screw A. The spring on the cutter gives a marking pressure. It may be fixed by screw B, and by the same screw the strength of the spring pressure can be regulated. Figs. 14 and 15 give acute angles, and the sections may represent a straight or circular plan. The two views show the spring, which is attached at C (Fig. 16), extended and contracted. The screw D sets the diameter of the circle required. In Fig. 17 is shown the operation of striking a circle inside a core box on a semi-circular surface. The small block X is to hold the centre point.

Band Saw Guides.

Fig. 18 shows a guide for a band saw. In most pattern shops the breaking of saws causes delay and annoyance; two or three sometimes break in a day. In most band saws that have come under the author's notice the guide of the saw has been provided with wood blocks, either all wood or wood blocks fixed in metal guides to steady the saw when running. At the slightest wrench the teeth catch the wood, straining the saw and wearing the blocks. In the guide illustrated the saw, whether for wood or metal, runs between four small pulleys in separate plates A and B, with springs attached when operating the saw. At the slightest twist the springs give, both

right and left, thus preventing at least half the breaking—a great consideration in the cost of brazing and renewals of bandsaws, as well as the time spent in refitting wood blocks into guides. In this case the guide is all metal. The back of the saw runs on hardened steel ball-bearing roller C. The cap is screwed to ¾ in. in gas thread to clear the ball bearing, the diameter of which is 22 m/m., and the shaft 8 m/m. The front and side elevations show the guide without the face plate D, which is screwed on last when plates A and B are in position. A detail shows the clearance for the back roller in plates A and B. The shank E must be made to suit the existing slide of band saw. The plan shows the plates in position and guide complete.

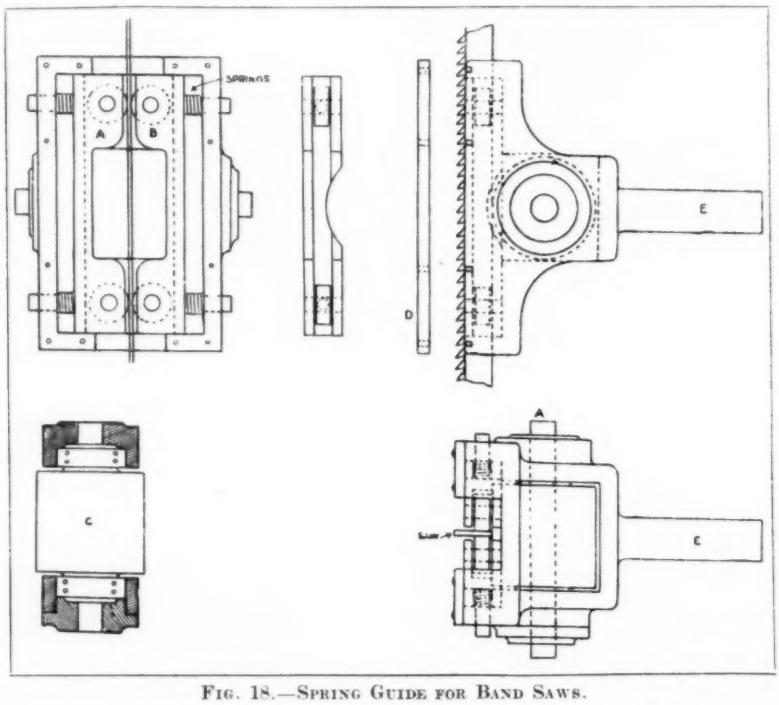


Fig. 18.—Spring Guide for Band Saws.

In conclusion, the author would like to express his thanks to Messrs. Chance Brothers, Smethwick, Birmingham, and to the Editor of the "American Machinist" for courtesies extended to him in the preparation of this Paper.

The Relation between the Tensile Strength and the Electrical Restivity of Commercially Pure Copper.*

By W. E. Adkins, M.Sc.

Summary.

The relationship between the tensile strength and the increase in the resistivity of commercially pure copper in the form of wire has been investigated for two sizes of wire (40 lbs. per mile; 200 lbs. per mile). For tensile strengths above 20 tons per sq. in. the relationship is practically a rectilinear one, and it is suggested that in drawing up specifications for the resistance of hard-drawn wire of tensile strength T tons per sq. in. the maximum resistance allowed should be equal to that of an annealed wire of the same weight corresponding to the international standard, plus an allowance of one-tenth of T per cent. (*i.e.*, $\frac{T}{10}$ per cent.).

Mr. Robert Crighton, chairman of board of directors of Harland & Wolff, Limited, has been elected a member of the Belfast Chamber of Commerce.

* A Paper presented to the Spring Meeting of the Institute of Metals.

The Brittle Ranges in Brass as Shown by the Izod Impact Tests.*

By D. Bunting, B.Sc.

Summary.

The brittle ranges exist in brasses of composition varying from 90 per cent. to 52 per cent. copper. The brittle range of the 52 per cent. alloy extends from 220 to 540 deg. C., and as the percentage of copper increases, the range reaches a minimum of 57.5 per cent. copper, extending from 320 to 540 deg. C. With further increase of copper the range extends upwards indefinitely, and at 65 per cent. exists from 325 deg. C. until the solidus is entered. At 75 per cent. an upper limit to the range is once more observed, the range now extending from 370 to 725 deg. C. Beyond this point the lower limit (hitherto practically constant at 325 deg. C.) rises until, at 80 per cent., the range extends from 430 to 630 deg. C. The range now narrows, and finally terminates in the neighbourhood of 90 per cent.

The influence of rapid cooling is to cause a general increase in the brittle ranges, due both to coring and to the production of increased quantities of beta.

It would appear probable that the brittle ranges are due to a failure of the intercrystalline cement which takes place during the transformations that occur both in the alpha and the beta solid solutions. These transformations affect the interatomic cohesion of the metal, and owing to the space-lattice distortion gradient or intercrystalline cement being unsupported by the bonding power of the space lattice, this effect is experienced to a much greater degree by the intercrystalline material.

Personal.

Dr. F. A. Bather has been appointed Keeper of Geology at the British Museum.

Mr. W. H. Bailey has been appointed a representative in London for Planet Foundry Company, Limited, of Guide Bridge, near Manchester.

Mr. A. Butcher and Mr. P. Brotherton have been elected directors of W. Canning & Company, Limited. Both have been in the company's service for many years.

* A Paper presented to the Spring Meeting of the Institute of Metals.

Metallurgical Control in Automobile Foundry Practice.

By A. Harley, M.I.Brit.F.

(*Continued from page 210.*)

Production of a Cast Iron Cylinder.

Fig. 6 shows the exhaust side of a 21-h.p. 6-bore monobloc cylinder; Fig. 7, the induction side; Fig. 8, a section through the barrels; and Fig. 9, the cylinder as delivered to the fettling shop.

The successful production of a cylinder calls for the close co-operation of the designer, pattern-maker, foundryman and metallurgist. To emphasise the importance of the foundry point of view on the question of design, a few points that had to be brought forward before the drawing for this casting was finally approved will be mentioned.

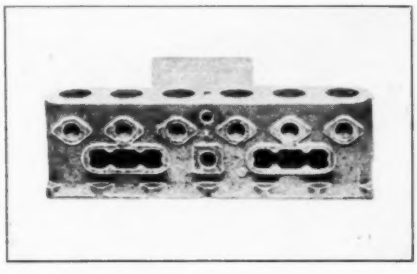


Fig. 6.—The Exhaust Side of a Six-Bore Cylinder.

In the first arrangement the induction of this cylinder was enclosed in the water jacket, but the designer was persuaded to leave one side open to make it possible for the mould to be made horizontally. The following points were settled at this stage:—(1) The pattern to be in halves, jointed through centre of bores; (2) jacket core to be in halves, also jointed through centre of bores; (3) the barrel cores to be made in two parts, each part containing three barrels; (4) induction bore-core to be made in one piece up to the joint of the mould. The other part of this core to be dowelled on the top and gummed; and (5) six separate exhaust cores to be used.

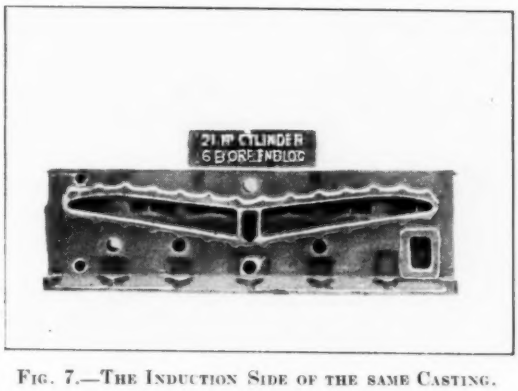


Fig. 7.—The Induction Side of the same Casting.

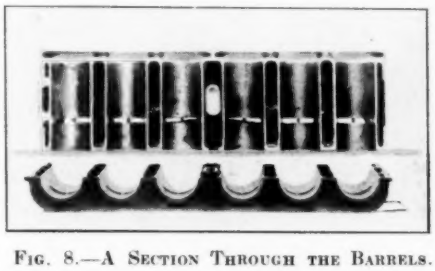


Fig. 8.—A Section Through the Barrels.

A Paper presented to the Sheffield Branch of the Institute of British Foundrymen, Mr. J. Shaw presiding.

As a matter of principle, the designer wishes to have as few holes in the jacket as possible, but certain requirements of the foundry and machine shop have to be met. The machine shop as a rule wants a small round hole on the centre line of each bore in order to locate from the barrels. The foundry also requires certain holes, so that the jacket core can be supported, and also for venting purposes. The foundry prefers these holes between the barrels where there is the largest body of sand, so that a compromise between the foundry and the machine shop on this matter has to be effected. In the present instance two oblong holes were made.

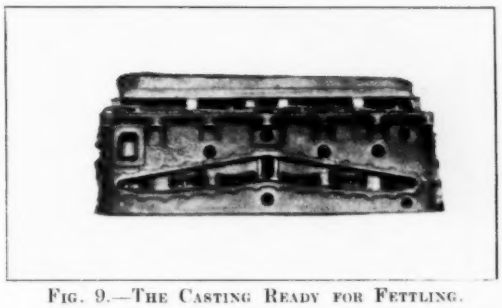


Fig. 9.—The Casting Ready for Fettling.

Fig. 9 illustrates the method of running the casting. There is an ample well from which the metal runs down the barrels. The small auxiliary runners which may be noticed in the figure are for the purpose of ensuring that the outside walls are run. The author favours casting with very hot metal and casting quickly.

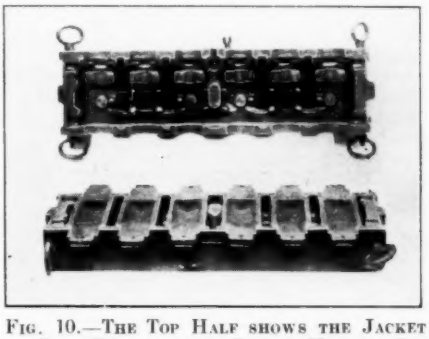


Fig. 10.—The Top Half shows the Jacket Core Box and the Lower Half a Set of Driers.

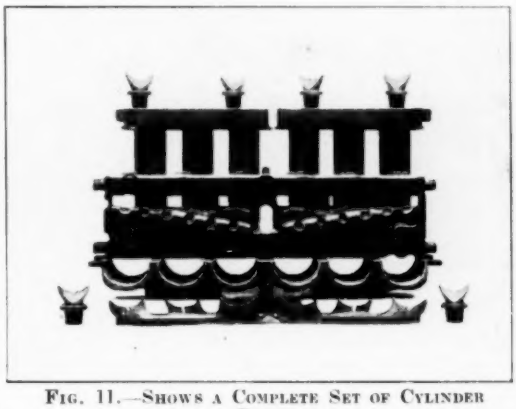


Fig. 11.—Shows a Complete Set of Cylinder Cores.

Fig. 10 shows the jacket corebox, one half showing the driers in position and Fig. 11 a complete set of cylinder cores.

The jacket coreboxes are made in cast iron. The use of silica sand has one disadvantage; it wears away wood coreboxes in a very short time. Several sets of barrels to form the outside of bores are fitted in each box, and when the core is turned out of corebox on to machined plates these barrels are left in until core is dried. These driers are

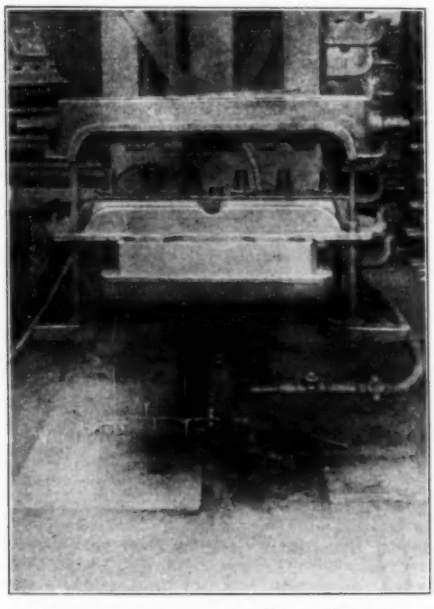


Fig. 12.—Shows a Six-Bore Cylinder Mould on the Machine.

really an integral part of the corebox, and enable the men to handle the core and get it dry without any risk of damage or distortion. The two sides of the corebox are loose, and the whole corebox is held together by two bolts. Bushes are inserted in the corebox to form small round projecting cores. This ensures these round projections coming out accurate.

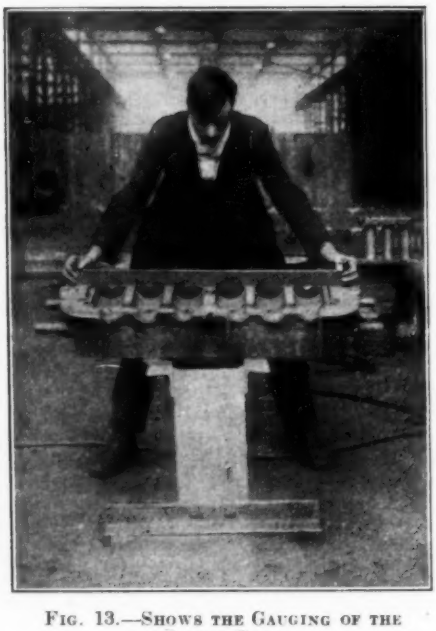


Fig. 13.—Shows the Gauging of the Jacket Core.

With regard to Fig. 11, the sand used for the jacket core is a coarse-graded silica. Certain parts have to be made in somewhat finer sand, and in the thick parts very much coarser material is used, almost the size of small pebbles. It is bonded by molasses, and thoroughly mixed in a mechanical mixer of the barrel type, and it can be used almost immediately, but is better for standing a short time. The prepared sand should be stored in a well-ventilated room, and in winter must be kept free from frost or trouble will ensue. Further, it is essential that molasses of the highest purity be used, and definitely free from any alkali. The question whether molasses is preferable to oil or other patent binders has been solved by test-

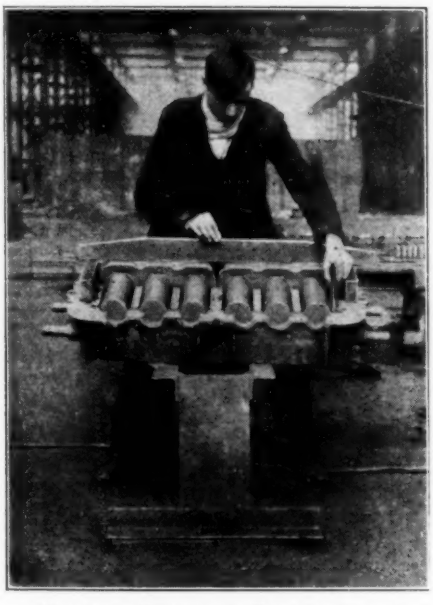


Fig. 14.—Shows the Gauging of the Barrel Core.

ing many of these, and while many of them have proved satisfactory in use, the cost has been found to be much higher.

The cores are baked at a temperature of 300 deg. C. for 20 mins., and are then passed to stores for inspection and gauging. The barrel coreboxes are also made in cast iron. These have runners recessed in them, so that each cylinder has the same amount of runner, and always in the same position. This core is made in ordinary sand, and has projections so that it is well supported when the mould is turned up for casting. The induc-

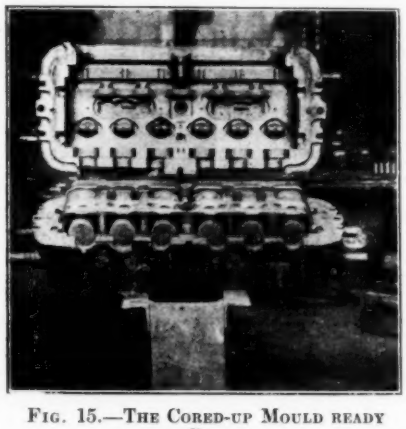


Fig. 15.—The Cored-up Mould ready for Closing.

tion corebox was at first made in wood, which was rather fortunate, as it was subsequently altered several times.

The exhaust corebox is made in cast iron, and has a collar larger than the actual hole required, which provides a good firm bearing. Figs. 12 to 16 show the process of making the moulds. Fig. 12 shows the cylinder mould on the machine, Fig. 13 the gauging of the jacket core, Fig. 14 the gauging of the barrel core, Fig. 15 the mould assembled ready for closing, and Fig. 16 the mould ready for casting.

Practically all the Daimler castings are machine moulded, by means of a pneumatic jarring-machine

which was originally designed and made in the works. Pneumatic machines require, of course, the installation of a compressor plant, and air at a pressure of 80 lbs. per sq. in. is used. The author advocates having the air pipes overhead. Originally they were placed in the floor, where leakages are not easily discovered, and it is more

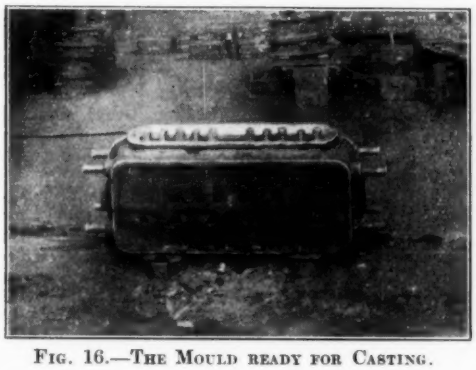


Fig. 16.—The Mould ready for Casting.

difficult to get rid of any condensed moisture; in fact, even with an overhead system condensed water is rather a bugbear.

The cylinder is moulded on its side, and boxes are designed and made in the foundry. The

Fig. 17.—A Rear Wheel and Back Axle Casing.

question of box plant is not a part of the equipment that can be scamped. The boxes should be accurately and well made, machined on the flanges, and the pin holes kept accurate. In this case the boxes are designed for a dried mould, and there-

Fig. 18.—A Wheel Pattern Mounted on a Moulding Machine.

fore the minimum amount of sand space is allowed. In America the casting of cylinders in green sand has made considerable progress, and British foundrymen will have to give more serious attention to this matter. The intricacies of British design may account to some extent for the lack of progress in this direction, but there is no doubt that many of our difficulties could be overcome by improving the quality of our sand mixtures. Recent experiments have shown that the strength of green sand can be enormously improved by specialised methods of preparation.

All the cylinder moulds are blacked by means of a pneumatic sprayer which does the job very quickly and effectively.

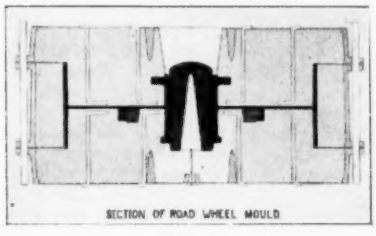


Fig. 19.

Production of a Cast Steel Road Wheel.

Fig. 17 shows a rear wheel with back axle casing, Fig 18 the pattern on the machine, and Fig. 19 a section of a road wheel mould.

Zirconium in Steel-making.

Before the American Institute of Mining and Metallurgical Engineers, at their general meeting on February 18-21, further information on the *rôle* of zirconium in steel-making was presented in an interesting Paper, entitled "**Effect of Zirconium on Hot-Rolling Properties of High-Sulphur Steels and the Occurrence of Zirconium Sulphide,**" by Mr. Alexander L. Feild (research metallurgist, Electro Metallurgical Company, New York). It is shown that from a consideration of the sulphur, manganese and zirconium contents of these steels, zirconium reacts with the sulphur of the molten steel in accordance with the equation $Zr+2S=ZrS_2$. The author finds that zirconium disulphide appears in the finished state as grey-coloured inclusions, similar to manganese sulphide in their plastic behaviour and general appearance. He states that zirconium completes its act of deoxidation before proceeding to combine with sulphur and indirectly increases the effective sulphur-combining power of any manganese which may be present. The sulphide content of the steels examined ranged from 0.075 to 0.320 per cent. Summarising the results, the author states that:—

Zirconium eliminates red shortness when present in the finished steel in the proportion of 1.41 parts or more of zirconium to 1 part of sulphur; the ratio 1.41 corresponds to the formation of the normal zirconium sulphide, ZrS_2. Zirconium sulphide, like manganese sulphide, is plastic at rolling temperatures and, in polished sections, is visible as ovoid or elongated grey inclusions. Evidence is offered in support of the view that oxygen is jointly responsible with sulphur for red shortness in steels that contain manganese only as a sulphur-combining element. Zirconium, unlike manganese, is not required in the finished steel in amount greater than that theoretically required for formation of zirconium sulphide, because of its powerful deoxidising action. In amount greater than that required to form the sulphide, zirconium confers on the sulphur content of the steel the property of insolubility in 1:1 hydrochloric acid, the percentage of sulphur thus rendered insoluble being proportional to the excess of zirconium in the ratio of 1 part of sulphur to 10 of zirconium.

In the course of a discussion, Dr. B. D. Saklatwalla (Vanadium Corporation of America, Bridgeville, Pa.) stated that the author, in discussing the chemical combination of sulphur and zirconium, had overlooked other data and conclusions. It was his belief, he stated, that zirconium was one of the most powerful deoxidisers, but he felt that this was secondary to its *rôle* as a coagulating medium, which explained in part its efficiency in removing sonims and other non-metallic impurities.

XUM

Liquid Steel for Castings.*

By T. E. Hull, F.C.S.

This Paper deals only with the subject of "liquid steel" as required for sand moulds in the production of steel castings. During recent years there has been considerable advance in the knowledge of the behaviour of metals during cooling from the liquid state, and, as regards steel, the special problem of ingot solidification and cooling has deservedly received greater attention.

It is not intended to touch upon the many problems which tend to the production of sound and homogeneous castings, for example, moulding sands, facing sands, method of moulding, gateing, risers or feeders, heat treatment, etc., each of which is alone subject enough for one Paper.

Let it be noted, too, that steel can be, and is, produced as sound or as poor by one process as another. Successful metallurgical operation, no matter what the process, is the most important factor.

The Control of the Slag.

After selection of materials for the charge the first point to be observed in the production of liquid steel of dependable quality is the necessity of very hot "melting down." Too much stress cannot be laid upon the necessity of superheating the bath of molten metal prior to the refining process. Quick and hot melting at this stage reduces the basicity of the slag formed by oxidation during the melting period, the proportion of silica to basic oxides composing the slag being a function of the temperature. When the charge is clear melted the addition of iron ore or, as in the case of the converter, the application of the air blast should never be commenced until the melter is certain that the bath is sufficiently hot. Experience often points that too little attention is paid by some steel makers to the melting temperature, which primarily governs the slag condition of a charge, the object being to make steel and not slag, the composition of the latter being of little interest, whilst they entirely overlook the fact that the quality of the steel is dependent upon the state of the slag. It is almost an axiom in practice that if the slag be right the metal will also be right. Limestone additions have a very valuable effect upon both slag and metal when added judiciously; these additions tend to obtain perfect equilibrium in the furnace bath by lowering the iron content of the slag, which can only occur when the metal has become thoroughly deoxidised. This condition is essential before the addition of the finishing alloys, if the subsequent production of steel of the highest quality is desired. In other words, limestone is added to the slag during the working of a charge with the object of steadily decreasing the concentration of FeO in the slag, so that by the end of the process the slag will contain a very low percentage of FeO and a correspondingly low concentration of the FeP in the metal can be expected.

Mr. Francis Samuelson, in his Presidential Address to the Iron and Steel Institute, May, 1922, said:—

"All practical steel makers agree in avoiding to the utmost any considerable percentages of iron oxide in the slag at every stage of commercial steel manufacture, and will readily understand the bearing of one difficulty stated, viz., the manufacture of a satisfactory molten product beneath a slag high in iron oxide. In open-hearth practice control of iron oxide in the slag is necessary on every account, but especially consequent to tapping to avoid casting troubles."

Slag Inclusions.

Every mass of steel contains inclusions to a greater or less degree, since it is impossible to manufacture steel without them.

Much defective steel is bad solely because of the amount of non-metallic particles which it contains, and quite the large number of failures due to faulty material have been or are traceable to this cause.

All the evidence is favourable to the view that FeO is in solution in liquid steel, and it follows that the addition of elements having a stronger affinity for oxygen than has iron will reduce both the amount of FeO and the amount of gases in solution.

In the class of inclusions formed by admixture, which embraces slag and fluxed material, and also with MnS inclusions, a high temperature refinement is beneficial for reasons which are purely physical, such as the increased fluidity of the liquid steel, enabling the inclusions to be free and not entrapped. Nor does the influence stop here, for the slag is in equilibrium also with the constituents in the steel, and by the partial law of temperatures the concentration of the FeO in the slag bears a relation to its concentration in the resultant steel.

Steel which is unduly impregnated with slag inclusions is correspondingly weak, and is very susceptible to "cracking" or "pulling" during solidification in the moulds, and too much emphasis cannot be laid upon the necessity of heating prior to refining. A high temperature of working implies not only less FeO in the steel, but also a more silicious or balanced slag. Every steel maker will agree that this deduction from theory is in accordance with regular experience.

The Influence of Dissolved or Occluded Gases.

All molten metols possess the power of absorbing or dissolving quantities of various gases, and it is indisputable that molten steel, no matter how carefully melted, contains a very considerable volume of gases in suspension.

It is commonly seen and well known by all practical foundrymen that pouring and feeding of a steel casting is accompanied by a vigorous gas escape through the feeding heads of the casting. The so-called shrinkage cavity is thereby being filled with molten metal, whilst the gaseous contents of the cavity is being ejected through the "head." There is no doubt that dissolved or occluded gases have a very important bearing on the shrinkage of steel at the time of its freezing and cooling in sand moulds, and, further, it can be stated that steel which has been highly superheated above its melting point shows a higher co-efficient of contraction than similar steel melted with little superheat. The need for cooling down in the furnace or ladle before casting such "superheated steel" is well known as an antidote to excessive shrinkage or piping troubles. This and similar experience subjects the connection between gas escape during freezing and feeding of castings and contraction.

It is also safe to assert, as a matter of experience, that steel produced by any of the converter methods is always liable to eject larger volumes of such dissolved or occluded gas than, say, a steel produced by either of the open-hearth or electric furnace.

Also in view of the effect of dissolved gases upon liquid metals in general, the terms "lively" as applied to converter steel can be more easily understood. Solidified steel, free from blowholes, however, does not necessarily mean steel free from gases.

Shrinkage.

It is unfortunate that considerable confusion exists regarding the definition of the term shrinkage. Shrinkage and contraction are synonymous terms, although an effort has been made to confine the former term by applying it to "liquid" contraction, whilst restricting the other to the volume change in the metal cooling from the freezing point.

Steel shrinks in volume with fall in temperature in three distinct states:—(1) In the liquid state; (2) in the liquid and solid state; and (3) in the solid state.

The shrinkage effect in Nos. 1 and 3 states will be uniform in rate and direction, whilst in the case of No. 2 state the conditions are variable,

* A Paper read before the West Yorkshire Metallurgical Society at Huddersfield.

seeing that the metal is undergoing a change of density with the change of state, which makes it clear that the higher the temperature at which the metal enters the mould, the greater the liquid shrinkage from its temperature at entrance to its temperature at freezing point. It is not an uncommon experience for castings to show little or no trace of piping in the feed heads, when by accident, through nozzle stoppage, the steel has become almost frozen in the ladle, but just retaining enough "life" to fill the mould, showing clearly the effect of temperature upon shrinkage.

At temperatures bordering on 1,150 deg. C. steel is very weak in the intercrystalline sense, which can be demonstrated when attempting to extrude or die draw it at this temperature region. It must be clear then that any condition which tends to keep the casting in contact with the moulds continuously and which assists rapid freezing, especially in the portions which are liable to fracture through irregular contraction, should be welcomed.

Liquidity and Fluidity of Steel.

A general statement has frequently been made that converter steel is more fluid than that produced by either the electric or open-hearth furnace, whilst very hazy suggestions as to this phenomenon have been advanced. It is the writer's opinion that converted steel possesses longer life in the ladle than steel produced by any of the usual methods. Too much stress has been placed on pouring temperature in considering this relationship, whilst the importance of the term "liquidity" as applied to steel provides an avenue of research still to be explored. Suggestions have been advanced with a view to explaining the "fluidity" of converter steel as follows:—By the presence of dissolved oxides; or by incomplete reactions between finishing alloys in the ladle; or through high temperature conditions.

It has been discovered from practical experience that no matter how hot the steel may be originally, if it is full of oxides it will chill rapidly in pouring. On the other hand, steel free from oxide inclusions will run when surprisingly cold, and seems to pour better.

In the author's personal experience, liquid steel is being poured daily from a stock converter plant with the minimum slag inclusions, as compared with high quality electric steel, with final reactions fully completed before entering the ladle, giving a perfectly dead melt. The steel, although produced under superheat melt and refining conditions, is cast at only a moderate temperature, having been cooled before tapping, and on casting into moulds is perfectly fluid.

It is suggested that the matter of dissolved and occluded gases, which is common to steel as produced by the converter, is a truer explanation.

The real difficulty confronting the investigator on the lines above suggested is the difficulty of obtaining comparisons of the three methods of production of liquid steel of even chemical composition and temperature control, together with a really reliable method of estimating oxide inclusions and dissolved gases. In the meantime, this important matter stops at assumption based on phenomena.

Chemical Composition.

It is fairly safe to say that with reference to steel for steel castings a sulphur content under 0.08 per cent. is not the "bogey" it has been considered to be in time past. The beneficial effect of manganese on steel has long been known, and the connection between the presence of sulphur and the neutralising effect of manganese is now fully appreciated.

Arnold was the first to show how the dangerous iron sulphide inclusion in steel was replaced by dove-coloured globules when sufficient manganese was present. It has been generally accepted since that the dove-coloured areas were composed of manganese sulphide and that the location of iron sulphide between the grains accounted for the red-shortness of steel containing little or no manganese.

Theoretically, one part of sulphur in steel requires 1.73 parts of manganese to form MnS, but, practically, more has been found necessary and desirable. Stead has stated that it is safer to have at least eight times the manganese content over the sulphur content up to 0.06 per cent. S, and this figure is at the present time generally adopted in works practice.

In view of the researches of Hackeney, Arnold, Brinell, Thompson and Stead, it has been shown that as the percentage of sulphur decreases the ratio of manganese to sulphur must be increased if the evil effect of the sulphur is to be effectively removed As a general contention, a manganese content of steel required for castings to give favourable results will vary between 0.8 and 0.9 per cent., thus assisting to give further fluidity to the steel, whilst mitigating to a very large extent against "shrinkage cracks" or "pulls." The silicon content of steel for castings is best kept between the limits of 0.25 to 0.35 per cent.

"Why Mild Steel Castings?"

In the issue of THE FOUNDRY TRADE JOURNAL of July 19, 1923, there appeared a very sensible editorial leader entitled "Why Mild Steel Castings?" which provided an exposition of the difficulty which presents itself in a practical way to all steel founders producing light and intricate castings. The article stated the obvious features and requirements of any steel casting in conforming to shape and size and the still fundamental feature of soundness, apart from which feature a casting is useless. The imposition of specifications, often of an unsuitable character, often compels the manufacturer to meet imposed tests rather than common-sense ones.

Most melters will agree that the lower the carbon the more difficult the steel is found to withstand the average pouring and mould conditions. Then again, the lower the carbon the higher the temperature at which the steel must be cast with the attendant risks through the process of pouring to the resulting casting itself. The only advantage procured by this method is that the resulting steel is in entire conformity to the specification imposed, whilst the disadvantages often are increased liability to the numerous casting defects to which all metals are heir; whilst it must appear ridiculous to save the extra machining costs, if a distinct uncertainty exists, even after several wasters may have been produced, as to whether the casting is sound. The axiom of this leader article must have special appeal to those who are daily up against the many problems which confront those in the high-pressure steel castings industry, viz., "first make sound castings." Good castings can be produced with a 0.2 per cent. carbon steel, but better and more consistently sound castings of the intricate and light section type can be more easily obtained with the maximum of soundness and reliability, coupled with less risk and failure, of a steel with a 0.5 per cent. carbon content. This is more particularly true of castings designed to withstand high steam pressure.

Finally, with reference to the use of "deoxidisers," it ought not to be necessary to say that such will not make bad steel good. The judicious use of aluminium in the ladle may be useful, and indeed beneficial, to a steel which has been properly killed in the furnace. Deoxidising should be commenced in the furnace or converter and completed in the ladle before the steel ever reaches the mould.

Most practical metallurgists will agree with the sentiment that liquid steel badly produced will reflect itself on the casting, in spite of the very elaborate and lengthy articles written complimentary to the virtues of any single deoxidiser.

CONCLUSIONS.

1. The starting and basic principle in the production of liquid steel is the necessity of hot melting prior to refining, with a view to controlling the balance of the slag components; this condition is assisted by the judicious use of limestone.

2. High temperature refinement is beneficial in producing a steel in which the slag inclusions are more easily removed owing to the physical condition of the bath; also, high temperature control at the refining stage produces a more siliceous or balanced slag, with consequently the minimum of FeO in solution in the finished steel.

3. The higher the temperature of refinement the greater the density of the resultant steel, a factor

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of importance in the case of steel required for high pressure castings.

4. Generally speaking, and especially for light and intricate work, the steel would be poured at as low a temperature as possible consistent with fluidity. This principle controls the following phases through which the steel must pass in moving from the liquid to the solid state :—

(*a*) Liberation of larger volumes of dissolved gases held in solution, thereby reducing shrinkage effect and indirectly lowering the total shrinkage of the mass for the coefficient of expansion or contracting rises with the temperature.

(*b*) Approaching nearer the ideal condition by bringing the liquid steel nearer to its congealing point and incidentally allowing minimum of erosive action on the sand runner and mould.

(*c*) The time period through which the steel, as cast, remains in its critical state of weakness when at its congealing temperature or weakest period.

(*d*) The "fluidity" or converter steel is largely governed by the quantity of dissolved and occluded gases. This fact is substantiated by the action of gases on molten metals in general, and is in a much less degree a matter of temperature.

(*e*) Chemical composition of the steel in a less degree governs this factor of "fluidity."

(*f*) It is a well-known fact that the lower the carbon in the bath the more oxygen is liable to be dissolved in the metal, as the carbon has less influence in removing it; as a result, there is more loss of manganese and silicon additions. For steel castings it is strongly to be recommended that the finished carbon be as high as possible consistent with giving on mechanical test results such as are called for by specification and with the best machining properties. It is also to be recommended for steel for intricate and pressure test castings that the manganese content should range about 0.8 per cent.

Obituary.

Mr. David David, of the firm of David Bros., Pencoed Foundry, died recently.

Mr. G. C. Kirby, formerly manager of the woodworks department of Ruston & Hornsby, Limited, died recently.

Mr. D. Drake, a director of James Mackrell & Company, Limited, of Union Foundry, Elland, died recently in his 65th year.

Mr. J. Clough, proprietor of the firm of Sam Clough, steel merchants and wire machinery manufacturers, of Sickle Street, Cleckheaton, died on March 2, in his 64th year.

Mr. A. H. Davies, who has died at his residence, Clyffard Crescent, Newport, at the age of 77, was for many years works manager of the Isca Foundry and Engineering Works at Newport, but retired in 1918.

Mr. J. R. Fyfe, who has died at the Gables, Boroughbridge Road, Knaresborough, at the age of 76 years, was formerly proprietor of the fire-brick making firm which bore his name at Shipley, his native place. He was also head of the firm of Fyfe, Kemp & Company, coal and lime merchants.

Mr. W. Burgin, the London manager of the Stanton Ironworks Company, Limited, near Nottingham, died suddenly on March 9, at the age of 50. Mr. Burgin had been for the last 20 years in the services of the Stanton, and previously Holwell Companies. His personality will be missed by his numerous friends in the industry.

Mr. Bernhard Grau, until a years ago manager of the Kraft Ironworks, of Kratzwieck, died recently. It is claimed that through his exertions Northern Germany was able to make herself independent of pig-iron imports from Great Britain, and even to compete with this country in her own markets. He had been the right-hand man of the old Prince Henckel-Donnersmarck, a well-known proprietor in the German iron and steel industry.

Lieut.-Colonel A. H. Laybourne died at The Firs, Malpas, near Newport, on March 10, at the age of 61 years. Colonel Laybourne was the elder son of the late Mr. Richard Laybourne, J.P., the head of the Isca Foundry and Engineering concern at Newport. The deceased gentleman was chairman and managing director of the Isca Foundry Company, Limited, and a director of the Tir-Pentwys Black Vein Steam Coal and Coke Company, Limited.

Trade Talk.

The Titanic Works of Clayton Wagons, Limited, have been closed indefinitely.

Mr. Leonard Peskett, naval architect of the Cunard Line, died suddenly last Friday.

The second International Conference of Women Engineers will take place in Manchester from April 2 to 5.

The Cargo Fleet Iron Company, Limited, are supplying 700 tons of steel girder tramway rails to the West Ham Town Council.

Hall, Lewis & Company, of Cardiff, and Moy's Wagon Company, Limited, Peterborough, have opened offices on the London Coal Exchange.

James Dunlop & Company, Limited, have closed their Clyde Ironworks, Tollcross, Glasgow, indefinitely, in consequence of the depression in trade.

Bolckow, Vaughan & Company, Limited, have removed from 15, Philpot Lane, London, E.C.3, to King's Buildings, Dean Stanley Street, Westminster, S.W.1.

Under the auspices of the Institute of Metals (Scottish Local Section) a lecture was given, on March 10, by Mr. G. Bernard Brook, on "The Romance of Aluminium."

An interesting lecture on "Structural Steelwork Production" was given at a meeting of the Walsall Engineering Society on March 11 by Mr. J. R. Charles. Mr. F. E. Thompson presided.

The men employed at the Middlesbrough works of the Linthorpe-Dinsdale Smelting Company, Limited, have received one week's provisional notice. Unless at the end of another week there is a material change in the situation, the two furnaces at the works may be damped down.

The members of the Institution of Engineering Inspection held their annual dinner at the Hotel Cecil on March 5. Mr. Francis R. Wade, the president, was in the chair. Those present included Sir Arthur Whinney, Brig.-General M. Mowat, Lieut.-Colonel P. R. Embury, Colonel David Lyell, Lieut.-Colonel J. H. M. Greenly, Mr. T. Clarkson, Mr. G. Watson, Mr. H. G. Dixon, Mr. C. Rowntree, Mr. A. E. Hadley, Mr. S R. Mullard, Mr. A. L. C. Fell, Mr. A. H. Foyster, Mr. W. Clifford Smith, and Mr. A. M. Sillar.

At Leeds, on March 6, Alderman G. Gummer, J.P., a Freeman of Rotherham, was entertained at a complimentary dinner on the occasion of his retirement from the presidency of the Northern Employers' Brassfounders' Association, after 31 years' service. Mr. H. A. Smith (Halifax), the president, was supported by Mr. R. J. E. Freeman (Birmingham), Mr. C. Braithwaite (Leeds), Mr. R. J. Nicholson (Dronfield), Mr. J. Vernon (Rotherham), Mr. F. H. Bruges (Rotherham), Mr. B. B. Blackburn (Birmingham), Mr. Dickinson (Rotherham), Mr. W. G. Gummer, Mr. W. H. Gummer, Mr. G. Gummer, jun., and Mr. C. J. Needle (secretary).

Contracts Open.

Johannesburg, April 10.—Tram track material, for the Municipal Council of Johannesburg. The Department of Overseas Trade.

London, S.E., March 28.—Motor-driven air compressor, for the Director-General, India Store Department, Branch No. 14, Belvedere Road, Lambeth, S.E.1.

Hoylake, March 24.—(1) Revolving screen or vibratory cascade screen; (2) picking belt, for the Hoylake and West Kirby U.D.C. The Engineer and Surveyor, Town Hall, Hoylake.

Cork.—2,500 yards 8-in., 2,400 yards 6-in., and 1,200 yards 4-in. cast-iron pipes and specials, for the Cork Gas Consumers' Company. The Engineer, Distribution Department, 72, South Mall, Cork.

Hucknall, March 24.—2,755 yards of 10-in. cast-iron water main, together with all appurtenant works, for the U.D.C. Mr. E. W. Bostock, Public Hall, Watnall Road, Hucknall. (Fee, £3 3s., returnable.)

Conway, March 24.—Supply, laying and jointing of about 1,380 yards of cast-iron s. & f. water pipes, 15 in. internal diameter, for the Conway and Colwyn Bay Joint Water Supply Board. (Fee, £2 2s., returnable.)

Pretoria, March 28.—Special manganese steel trackwork, also small quantity of tram rails, including fittings and bonds, for the Municipality of Pretoria. Beckett, Son & Company, Suffolk House, 5, Laurence Pountney Hill, London, E.C.4.

Licences under the Non-Ferrous Metal Industry Act, 1918, have been granted to W. E. Deeks & Company, Limited, Suffolk House, 5, Laurence Pountney Hill, Cannon Street, London, E.C.4; and A. Ogden, 3, Heathbank Road, Stockport, nr. Manchester.

Discussion of Mr. Smalley's Paper on the Cylinder Problem.*

COVENTRY BRANCH.

Steel Shot for Chilling.

THE PRESIDENT (Mr. C. Dicken, M.I.M.), said Mr. Smalley was a well-known figure in the metallurgical and foundry world, and had given them a most interesting lecture on foundry and cylinder problems which was particularly practical and instructive.

A VISITOR remarked that Mr. Smalley had mentioned the use of steel shot for overcoming porosity. Could he give details as to how the shot was to be used? He took it that the lecturer meant it was used in facing sand in some way, and an explanation of the point would clear up some doubt in his own mind as to the method of dealing with shot in sand.

MR. F. H. HURREN confessed that he had learned much from the lecture, and, referring to steel shot in sand, asked if Mr. Smalley had ever found any difficulty with the shot owing to its uniting itself with the casting. That was to say, the heat of the metal caused the shot, at any rate on the surface of the core, to adhere to the casting. He had some painful recollections of trying chills on cast iron on several occasions, and at times the chill became an integral part of the casting, with the result that the entire lot had to be consigned to the scrap heap. The figures that Mr. Smalley gave on the screen as to the effect of moisture on the bonding of sand somewhat astonished him. Very often it was the practice in foundries to allow the labourer to wet down the sand, but it appeared to him to be a job for scientific application, as the lecturer had plainly shown. The very small differences in the percentage of moisture were, he noticed, accompanied by a marked difference in permeability, and he thought that if anyone worked on the lines indicated by Mr. Smalley, they would find that a green-sand mould could be made which would stand up a great deal better, and, as the lecturer said, save the trouble and expense of drying. If he understood Mr. Smalley rightly, there was one point on which he did not agree with him, for he gathered that he said Brinell hardness was no indication of the life of a cylinder. For many years they had taken at his firm's foundry Brinell hardness numbers on different portions of the casting for cylinders, and they always took particular Brinell numbers on particular parts. The result was that they found two things: first, that the Brinell number was an indication as to whether the machinist was coming down to grumble about the casting being too hard; and, secondly, that when the Brinell number was low, they would probably meet with a complaint from the customer some months later that the cylinder was wearing badly. They endeavoured from years of test experience to keep their Brinell numbers within a certain range, and whilst they did this they invariably found that they could obtain a cylinder with a fairly long life. He would not say the test was a complete indication of the life of a cylinder, but it did give some knowledge as to what one might expect.

THE AUTHOR'S REPLY.

Mr. Smalley informed his audience that the use of steel shot had been confined to cores only. The quantity necessary is determined by the rate of cooling desired. Where a small hole is to be cored out of a large mass of metal, the core should be made entirely from steel shot, bonding with any well-known core oil such as linseed oil. Where such rapid cooling was not necessary the steel shot may be mixed with sea-sand or a moulding sand in any desired proportion. He could not give definite heat-conductivity figures for the varying proportions, but some idea could be readily formed by assuming the heat-conductivity of the steel shot to be 12 times that of sea-sand. In the use of this material it is important to keep it free from rust. It may be separated from the sand by passing through a magnetic separator or by jigging. Answering Mr. Hurren, the lecturer said he had not experienced any difficulty from the metal burning on to the steel shot or on to the ordinary solid chills. He recommended the use of a graphite, or graphite-china-clay mixture as facing mixed with kerosene. Chills should never be made from a low melting-point phosphoric iron, or trouble will be encountered from seizing.

The Brinell Test.

Possibly, Mr. Hurren had misunderstood his remarks regarding the Brinell test. He did not say that the Brinell test was of no value in determining the life of a cylinder, but that it was not a measure of tenacity hardness or hardness as is generally understood by the term. It was not a test that could be used universally as a standard measure of the life of a cylinder in service. It was, nevertheless, useful for control purposes in individual foundries. It afforded useful information on the texture, solidity and machinability of cast iron. In reply to Mr. Judd, regarding the design of a pyrometer for measuring the temperature of cast iron, he would refer him to a pyrometer, full particulars of which were given in the "Proceedings of Institute of British Foundrymen," 1921-22, page 698. This pyrometer had been in daily use for three years, and the total cost of upkeep was less than £10.

SHEFFIELD BRANCH.

THE PRESIDENT (Mr. John Shaw) mentioned that Mr. Smalley's position as a technical adviser to a large concern made it necessary that he had not only to discover defects, but he had to put them right.

Aluminium and Blow Holes.

MR. ROBINSON said he (Mr. Robinson) had encountered blow holes which were not blamed on to the sand. He would like to know whether the lecturer had ever come across blow holes in castings which were ascribed to a small percentage of aluminium in the iron. At the present time this was a thing in which he was particularly interested. The percentage had only been about 0.04 of aluminium in the iron. The lecturer had mentioned the structures of cylinder irons, and he had also given the compositions. Recently he had been in conversation with a fairly high authority in the Midlands with regard to cylinder irons for motor work, and he recommended a fine-grained cylinder iron, but if they had to produce such a structure by reducing the phosphorus content by using hematite it would be difficult to make them mix thoroughly and at the same time to give the fine grain necessary for cylinder castings. During the war foundrymen were all more or less up against a specified phosphorus content in the composition of cast iron supplied for war measures. In order to get that down it was always necessary to use either a certain amount of steel or hematite in the mixes. This question had cropped up whether by mixing a large quantity of coarse-grained iron in the shape of hematite with a cylinder iron which had a higher phosphorus content than was required, it would mix and produce a suitable cylinder grain. A lecturer at Coventry had stated that between 0.3 and 0.8 per cent. phosphorus gave a greater danger zone than when it was below 0.3 and above 0.8 per cent. With regard to one of the specimens shown of the running of locomotive cylinder castings, he once had charge of a shop where they were making locomotive cylinders, and they were all cast on the flat. They never had one returned. He was very much more in favour of running them straight down, and not, as the lecturer said, running part in at the bottom and part at the top. Mention was made with regard to milling sand and permeability. Had Mr. Smalley any experience with regard to the milling of sea sand and oil? Did he consider there was any damage done by milling it, and would it have a detrimental effect on the permeability?

Strength to be Associated with Thin Sections.

MR. EVANS, referring to the question of design, pointed out that getting a thicker casting did not strengthen it. In fact, in many cylinder castings they could take off 30 per cent. of the weight and get a stronger casting. If some of the difficulties of the foundryman were understood in the draw-

* This Paper appeared in our issues dated February 21, February 28, and March 6th.

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ing office much of their trouble would be overcome. He thought the castings were better run through quickly.

Mr. Edginton, speaking of L. P. marine engine cylinders, thought that slow running would be detrimental. With regard to the chaplets, views of which the lecturer had shown them, he thought it was a question of the temperature of the metal run into the mould, whether they obtained a proper weld of the chaplet. If the metal was run fairly cold, one could never hope to get a tight welding round the chaplet. The lecturer had shown a slide of a locomotive cylinder which had been run horizontally, with the trouble that dirt gathered round the port cores. That trouble occurred when they were run vertically, the only difference being that the trouble appeared lower down in the bore.

Mr. Green thought that slow running and dull metal was one of the worst things that the foundryman had to deal with.

Flat or Vertical Casting for Cylinders.

Mr. Webster said that, so far as cylinder making went, casting them on the flat, he would be inclined to say that with hot melting and hot pouring there was not very much more risk than there was in any ordinary engineering casting that required to be of good finish. Had Mr. Smalley had anything to do with 20-in. dia. piston valve loco. cylinders? If he had, which way would he cast them, how would he run them, how would he propose to feed them, and what were the common difficulties generally met with?

Co-operation.

Capt. Didden, speaking more as an engineer than a foundryman, said he would like to see more co-operation between engineers and foundrymen. His own experience, both in Europe and in America, had been that there had not been anything like the co-operation between the two that there should be. It was rather interesting on this point to recall the Presidential address by Sir John Durance a few weeks ago, in which he made that same remark. Coming from a man of the calibre of Sir John, and being mentioned that night by Mr. Smalley, it showed the tendency to-day that engineers and foundrymen were beginning to realise that there should be greater co-operation. One thing that Sir John mentioned was that most of the apprentices in the engineering trades to-day did not go into the foundry as much as they should do. They worked by rule of thumb laid down by their predecessors, and they knew very little of the actual foundry conditions. A boy in the engineering trade had a superficial knowledge of what was going on in the foundry, but 99 per cent. of the apprentices could not answer if they were asked the reason certain things were done. In the future it should be laid down as part of the curriculum that engineer apprentices should have a course in the foundry. This would give them a sound knowledge, so that as engineers they could appreciate the many difficulties which foundrymen had to meet.

Casting Temperature for Loco. Cylinders.

Mr. Pemberton remarked that Mr. Smalley had told them some of the methods of eliminating difficulties, but he was not quite sure whether they were altogether practical of accomplishment in the foundry. One of the points raised was with regard to the Brinell hardness test. He understood Mr. Smalley to say that this did not indicate the life nor the hardness of the casting. What did it indicate? He would like to know the correct temperature at which to run a locomotive cylinder.

THE AUTHOR'S REPLY.

In reply to Mr. Robinson, Mr. Smalley said he did not see how 0.04 per cent. aluminium could be blamed for the blow-holes referred to. Until further information was forthcoming with regard to the composition of the iron and the mixture used in the cupola, it was impossible to make any further remark. With regard to the milling of sea sand and core-oil, his experience was that, provided a light mill was used—the time of milling was less than five minutes—there would be no derogatory effects.

Permeability and Strength of Moulding Sands.

In reply to Mr. Evans regarding moulding sand tests, *permeability to gas and strength should* go hand in hand. It was usual to find the bonding strength was increased at the expense of the venting power. The only method to obviate this and obtain the desired combination of bonding strength and permeability was by testing the sand in the manner outlined. As to "rate of running," he thought Mr. Evans had misunderstood him. He did not advocate either slow or quick running of cylinder castings. The terms permitted too wide a latitude in their expression. He had shown them on the screen certain results obtained from a complex casting when every variable had been eliminated, as far as was practical, except the "rate of running," which is an important factor in the control of the "solidity or soundness" of cylinder castings, one that must receive due consideration. Without taking precise examples, it was very difficult to say whether a cylinder mould should be filled quickly or slowly.

Vertical Casting Preferred.

Answering Mr. Edginton, the lecturer said that casting cylinders vertically was, on the whole, preferable to casting flat, owing to metal having a freer flow and to there being less chance of trapping scum. Should any difficulty be encountered with the latter he advocated bellying the barrel core at the ports, or passing a riser through the port to the head of the casting. Neither of these should be necessary if the metal is melted correctly, poured hot, and the casting is suitably run. If with these precautions the design is such as still to give trouble, he recommended the use of a bottom-poured ladle.

Answering Mr. Green, Mr. Smalley said that he used chill-cast pig-iron for the reasons outlined in the Paper. Such iron is also cheaper than sand-cast pig-iron, and is more economical in use.

Science—Not Chemistry.

In reply to Mr. Webster, the lecturer said that unless the moulds could be prepared from day to day with a certain assurance that similar conditions were being reproduced, he could not see how it was possible to avoid making bad castings. He had suggested sand tests and a control of other factors to this end. If Mr. Webster had such a control of those factors, although he could not figure it out in technical terms, then his castings were assured, and he had in his foundry *scientific control. Science is too commonly associated with the chemist*, a being often learned in many theories which have not been proved. *Science is knowledge, and the aim of science is to reduce manufacture to a precise basis.* With regard to the cylinders referred to, he always cast that type vertically, running from the bottom quickly until the mould was nearly full, then he opened three top jets, spaced equally round the flange. He did not advocate a feeding rod but preferred to adjust his risers so that they could automatically feed or counteract any draw that might occur. At the heavy section above the ports he used chills. He agreed with the remarks made by Capt. Didden with regard to the training of apprentices, and considered it to be one of the most serious problems of to-day. In reply to the question by Mr. Pemberton as to the best temperature for casting locomotive cylinders, he said that the range he used was 1,325—1,340 deg. C. With regard to the Brinell test, he suggests that this measures solidity and not hardness as is ordinarily understood by the term.

A resolution of thanks was accorded Mr. Smalley.

Gazette.

An order approving a composition offered by Messrs. G. L. Grace and T. H. G. Childs, metal merchants, lately carrying on business as Grace & Childs, at Howard Chambers, Norfolk Street, Sheffield, and at 19, North Church Street, Sheffield, has been annulled. The grounds of annulment are that a sufficient sum of money to provide the 6s. 8d. in the £ as proposed by the composition has not been paid to the trustee.

Repair and Upkeep of Pneumatic Tools.

In the course of a Paper on the "Repair and Upkeep of Pneumatic Tools," read before the February meeting of the Institution of Mechanical Engineers, MR. R. W. WILSON, the author, remarked that pneumatic tools were used in rough surroundings, and were operated by men who would also, perhaps unthinkingly, be characterised as rough. They must therefore be rough and strong externally so that they could withstand the most strenuous use and unlimited abuse, yet in the details there were scarcely any machines so carefully made and so precisely sized in all responsible dimensions. Only a small percentage of repair men (continued the author) ever learn exactly why or how these tools operate, but if they remember that they worked properly when they left the factory, and learn to keep them in their original condition, it is all that is necessary. As tools come in for cleaning the repairer should check their air consumption by comparison with a standard tool, examine carefully the surfaces which are supposed to fit together with an air-tight joint, remove any burrs with a very fine flat file, take away the sharp corners, and countersink the pinholes slightly.

The repair man should try, on a heavy block of wood arranged for this purpose, one of the hammers which is known to have sufficient power and work smoothly. With the working characteristics of this hammer as a standard, he will soon learn how fast a tool ought to run, how much vibration is to be expected under normal conditions, and how rapidly the sett ought to cut into the wood when the tool is developing normal power. With these standards in mind he can test doubtful tools, and judge by comparison whether they are right or wrong. A good repair man will soon be able to state positively whether they are right or wrong, and readily diagnose faults.

The lubrication of pneumatic tools must be done judiciously. For pneumatic hammers, on no account must heavy oils be used; these tend to gum up the valves and may prevent the tools from working. A light machine-oil is the best to use. The way to oil the tool is to pour a little light machine-oil into the air-supply passages or opening before connecting on to the hose. When the tool is started the air will carry this oil into all working parts, and while the tool continues at work no further lubrication is necessary. It is desirable that every pneumatic hammer in use should be immersed occasionally in a box of mineral oil for a thorough cleansing, and if a tool has been lying in store for a period it should be also immersed in the oil bath previous to use and then lubricated as already described. Important economies can be effected by paying careful attention to such matters as the sorting, cleaning, testing, maintenance of pneumatic efficiency, the carrying out of minor repairs, and lastly, the system adopted of issuing the tools to the operators.

In a well-maintained plant there must be no leakages. Leakages are most usually found in the flexible hose-lines and connections. If left to themselves workmen will suffer leaks which cause them no inconvenience rather than stop their work for the purpose of obtaining a new hose-line. Where a number of tools are in use it is an economy to employ a man whose duty it is to go round inspecting the pipe-lines, re-wiring on leaky connections, and on occasion purposely to cut a leaky hose-line to compel a workman to go to the store for a new length of hose.

Another fault which is often met with is loss of pressure at the point where the tool is used. Nothing is so fatal to the efficiency of pneumatic tools as a drop in the air-pressure. Pipe-lines are sometimes overloaded, and too many tools are supplied from a main much too small in diameter. Another fault frequently met with is the throttling of air in the connections. Some connections are very bad in this respect. It pays to have machined holes through connections made as large as possible compatible with the strength of the couplings. Another source of trouble which requires careful watching are strainers. They are very necessary sometimes, especially in dirty or dusty places, but they are liable to get choked up at times very quickly. Makers usually fit strainer adapters to all tools, and it not infrequently happens that a mysterious loss of power in a pneumatic tool may be traced simply to the gauze in the strainers getting choked up with dirt. These strainers are very easily cleaned by blowing air through the opposite way.

Water in the pipe-line is a frequent source of trouble. This is generally due to the after-coolers and air-receivers being too small, the hot air from the compressors not being properly cooled before entering the main. Moisture tends to choke the tools, and not infrequently causes ice to form in the valves and at the exhaust; also, it always tends to rust the internal parts of the tools, and thus may cause much damage.

In order to ascertain the real worth of a pneumatic tool, it is obvious that some ready means of comparing one tool with another is essential. Opinions of workmen as to the merits of any particular make of hammer are largely influenced by prejudice and the hammers they are accustomed to operate. In comparing hammers the following are points to which consideration must be given:—(1) The actual time in doing a definite amount of work, say, closing a rivet; but to compare hammers in this way a knowledge of the weight and frequency of the blow is essential; (2) freedom from vibration, which enables the operator to use the tool for longer periods without undue fatigue; (3) the weight, in order to avoid tiring the workman, by having to hold up a heavy tool; (4) flexibility and ease of control, so that light and heavy blows may be struck at the will of the operator.

With pneumatic drills comparisons are usually made by simple timing when drilling a definite diameter and depth of hole through a mild-steel plate.

Tests of a machine designed by the author as a ready means of comparing the weight and frequency of the blows of pneumatic hammers have given interesting results. The weight of the blow is ascertained by gauging the crushing effect on prepared test-pieces in given periods of time and the frequency of the blow by comparing the wavy line produced on a moving strip of paper by the action of the hammer, with a similar wavy line produced on the same piece of paper by a tuning fork of known vibrations.

Curves constructed by the author show the very great loss in efficiency which takes place when the air pressure is dropped from 100 lbs. to 80 lbs. They show that the same amount of distortion can be produced on the test-piece in about half the time with air at 100 lbs. than with air at 80 lbs., and as only about 10 per cent. more power is required to produce compressed air at 100 lbs. over compressed air at 80 lbs., it indicates how very important it is to use the maximum air pressure at which the tools are designed to work to attain the best results. Further, when it is considered that most pneumatic riveting is hot riveting and the rivet all the time is rapidly cooling, the importance of maintaining high air pressure at the point where the tool is to be used cannot be over-emphasised. This is indeed the crux of obtaining quick and sound work, and when these conditions prevail there is no fear but that pneumatic riveting will beat hand riveting not only as regards time but as regards the quality of the work produced.

Calendars, etc., Received.

Since publishing our last list we have received the following:—**Messrs. John & Edwin Wright, Limited,** Universe Rope Works, Birmingham, manufacturers of foundry crane steel ropes, etc.—Monthly tear-off wall calendar. **Messrs. Robert Hyde & Son, Limited,** Sheffield and Chesterfield, iron and steel founders. A novelty leather combination card, note and season ticket case.—**Messrs. Augusts' Muffle Furnaces, Limited,** Halifax, furnace designers. A tear-off monthly calendar.—**Messrs. Smeaton-Wright Furnaces, Limited,** St. Stephens House, Victoria Embankment, London, S.W.1, steelworks engineers and furnace builders. A monthly tear-off wall calendar.

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Determination of the Thermal-Coefficients of Expansion of Some Chemical Metals and Alloys.*

By J. Newton Friend, D.Sc. Ph.D., F.I.C., Member, and R. H. Vallance, M.Sc. (Birmingham).

Having had occasion to determine the coefficients of expansion with rise of temperature for a considerable number of commercial metals and alloys, it was thought that a brief description of the apparatus used and of the results obtained might be of use, as the method is simple and rapid. The apparatus is shown in outline in Fig 1, and consists of a steel tube, A, 27 in. in height and 3 in. in internal diameter. The lower end is screwed into a collar, which is bolted with four bolts on to a heavy steel or cast-iron base, measuring 12 × 12 sq. in. in area and ½ in. in thickness. This rests on four small studs in a heavy iron tray fitted with an exit tube, M.

Four sets of four small studs project annularly at regular distances, D, E, F, G, within the tube to support copper discs (shown enlarged at the side in Fig. 1) 0.035 in. in thickness, and of diameter just sufficient to enable them to enter the tube and rest comfortably on the studs. The central holes, H, are of varying sizes, according to the diameter of the bars of metal to be tested, whilst the four small holes in the rim are only 0.25 in. in diameter, and allow the steam, entering at B, to

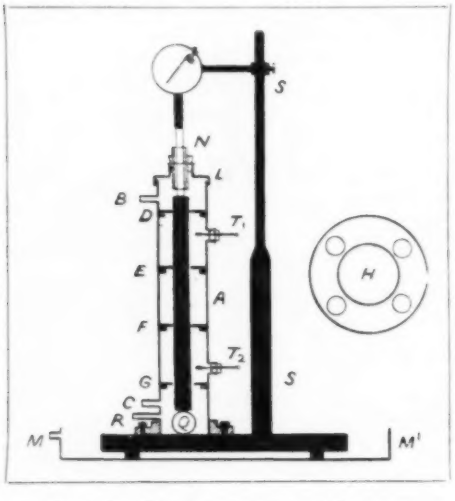

Fig. 1.—Determination of Thermal Coefficients, etc.

pass freely through the tube and escape at C. Two small necks admit of the insertion of the thermometers T_1 and T_2.

The top of the tube is closed with a screw cap, L, fitted with a neck into which a bung carrying a quartz tube, N, is fixed. The metal bar to be tested rests on a quartz cylinder, Q, chosen because quartz has a negligibly small coefficient of expansion. On the upper end of the bar rests a quartz rod which just slides through the quartz tube, the movement being facilitated by means of glycerine, the presence of which also prevents any steam escaping in this direction. The upper end of the quartz rod supports the base of an Ames dial gauge, the body of which is rigidly clamped to the upright steel bar, SS, which is kept at a constant temperature by a water-cooled jacket, not shown in the figure. It is necessary that SS should be perfectly rigid. Its lower diameter is 1 in.; its upper, ½ in.; and it is firmly secured to the base. The trough, MM′, is kept at constant temperature by flowing water, and condensed steam, instead of collecting at the bottom of A, drains through a small tube, R, immediately below C.

On beginning an experiment, the metal bar is placed in position and a current of water passed in at C and out at B, R being temporarily closed. When a steady state has been reached the dial zero is noted, the water is disconnected, and steam admitted at B. The reading of the dial is taken at this higher temperature, and from these data the coefficient of expansion is calculated.

The accuracy of the experiments is largely determined by the sensitiveness of the dial gauge. This is graded to 0.01 in., and the divisions can be estimated to one-fifth, so that if the dial is accurate the readings may be made to 0.002 in. In an ordinary case, using 24-in. bars of metal, the expansion corresponds to 30 or 40 divisions, so that the manipulation error is appreciably less than 1 per cent. This is sufficiently accurate for most commercial practice, as the metals differ among themselves by fully this amount. A true test of the relative accuracy of the results would appear to be the ease with which "repeat" results can be obtained, and the experiments Nos. 1, 2, and 5, 6, in Table I show that this is all that can be desired, as the duplicate determinations were made after intervals of two months in both cases.

Table I.—*Table of Coefficients of Expansion.*

Temperature range, 10 deg. to 100 deg. C. (approximately).

No.	Metal.	Co-efficient of expansion × 10^6.	Remarks.
1	Copper E	17.4	From the Broughton Copper Co., Ltd., Manchester.
2	Copper E (2 months later)	17.6	"
3	Copper	17.2	"
3	Copper B	17.2	"
4	Copper G	17.9	"
5	Copper	17.8	From the Muntz Metal Co., Ltd., Birmingh'm
6	Copper (2 months later)	17.8	"
7	Nicrocopper	17.7	"
8	Arsenical copper	17.4	"
9	Muntz metal	19.8	"
10	Naval brass	20.2	"
11	Nerganden brass	19.4	"
12	Screw metal	20.3	"
13	Aluminium	From	the British Aluminium Co., Ltd., Staffordshire.
14	Lead	29.5	From Cookson Co., Newcastle.
15	Lead with antimony	29.4	
16	Nickel	13.3	From the Mond Nickel Co.
17	Zinc	32.0	From the London Zinc Mills.
18	Commercially pure iron	12.3	Armco. Carbon, 0.25 per cent.
19	Wrought iron	12.3	From the Etna Iron and Steel Co., Carbon, 0.06 per cent.
20	Manganese steel	18.3	From Edgar Allen, Sheffield, Manganese, 12 per cent.
21	Stainless steel (i.)	11.5	Firth's Stainless, Chromium, 11.73 per cent.
22	Stainless steel (ii.)	11.7	"
23	Stainless steel	11.0	From Howell Co., Sheffield, Chromium, 13.40 per cent.

During an experiment it was found that on first passing steam through the apparatus the dial hand moved gradually to a maximum, but on continuing the passage of the steam, the dial reading diminished slightly and then remained steady. On cooling again with water, the hand moved back to a point behind zero, the difference in the two readings for expansion and contraction not always being the same. On readjusting the zero, however, and again passing steam, the dial moved to a maximum and remained steady, the expansion being numerically equal to the contraction in the first experiment, and, on cooling, the dial again returned to the new zero. This shifting of the zero, therefore, appears to be due to the bar accommodating itself to the apparatus.

The dial gauge was standardised by calibration with a spherometer, and the necessary corrections have been embodied in the accompanying table. The results obtained are given in Table I.

All the metals have been presented to one of the authors by the firm mentioned, and represent their regular commercial products. The authors desire to tender their sincere thanks to the firms concerned.

* A Paper presented to the Spring Meeting of the Institute of Metals.

A fire occurred recently at the Hook shipyard of the Ouse Shipbuilding & Repairing Company, Limited, one end of the platers' shed being burned down and a quantity of machinery damaged.

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Conditions in the Cleveland iron trade disclose little improvement since the last report, the general tone of the markets continuing inactive and depressed. The movement recently tending to lower prices has, so far, failed to stimulate business, and the few transactions recorded are mainly confined to buying in retail quantities to meet the pressing requirements of the moment. As is usually the case in a falling market, buyers are naturally inclined to reserve in anticipation of still lower values materialising, and even now hesitate to believe that actual rock-bottom values have been reached. There can, however, be little doubt that the price concessions recently announced have failed to achieve the object intended, and makers are therefore faced with the unwelcome alternative of producing at a loss, or greatly restricting the already limited outputs at furnaces. Confronted with the prospect of continued, if not continuous, labour unrest in all directions, the prospect for ironmasters is one of the most serious problems the industry has yet experienced, and until some satisfactory solution of the trouble can be found, the outlook must remain discouraging in the extreme. Meanwhile makers are exerting further efforts to induce business, and at this week's market the standard No. 3 G.M.B. quality was continued at about 91s. 6d. per ton, with even lower figures reported. No. 1 was about 95s. to 96s., No. 4 foundry 90s., and No. 4 forge 89s. to 89s. 6d. per ton.

In the Tees-side hematite market, also, further weakness has developed, if anything more so than in foundry iron. Supplementary to the already reported furnace blown out, another local firm will probably be damping down two others immediately, and unless trade quickly improves there will be further reductions of output. The general quotation for East Coast mixed numbers is now 99s. 6d. per ton, and makers are not disposed to shade this figure. No. 1 is obtainable at a premium of from 6d. to 1s. per ton. On the North-West Coast conditions are somewhat similar to those above described, Bessemer mixed numbers being somewhat below the figure at which they are quoted, makers in some instances being willing to accept 1s. per ton less than 115s. per ton delivered at Glasgow and Sheffield, and 120s. per ton at Birmingham.

MANCHESTER.—The continued depression in the Lancashire foundry industry has had a naturally corresponding effect upon the local pig-iron market, and business can only be reported on a hand-to-mouth scale. The nominal price in Manchester for No. 3 Midland iron is 102s. 6d. per ton, and although some of the furnaces in Northamptonshire have been reducing their prices, their iron when delivered here would cost as much as Derbyshire iron.

THE MIDLANDS.—Recent concessions in prices of foundry iron in this area have had little effect as far as demand is concerned, and business remains flat and uneventful. It is now said to be possible to buy some Derbyshire iron at 94s. per ton, f.o.r. furnaces, but Staffs and Northants makers are still holding out for the figures which have obtained of late, and perhaps will continue to do so until their present orders are executed.

SCOTLAND.—The position in the Scottish pig-iron markets remains exceedingly quiet, with prices evidencing a tendency to further weakening. The price ruling for No. 3 foundry is 100s. per ton f.o.t. furnaces, but for a line this figure could be improved upon. The quotation for Cleveland iron has eased again, and No. 3 is at 93s. per ton at Grahamston, with No. 4 foundry 1s. per ton less. No. 3 Continental is still being offered at widely differing prices, but the quotation is about 93s. f.o.t. Grahamston.

Finished Iron.

At last week's Birmingham market it was reported that business in the finished iron departments was comparatively active, due, perhaps, to the large orders now in course of execution at the local railway wagon and carriage works. Consequently most of the South Staffordshire bar mills are well employed, with sufficient specifications on hand to keep plants busy for some time ahead. Considerably more tonnage of orders for nut and bolt iron has come to the local manufacturers, because of the inability of the consumers to obtain regular supplies from the Continental sources with which they placed heavy orders in the early part of the year. Prices for marked bars are unchanged at £14 10s. per ton f.o.t., with Crown qualities firm at £12 10s. delivered.

Steel.

Movements in the various branches of the steel industry at present are without special significance, and buying is again reported on restricted lines. There is only a limited demand for basic billets, which have slumped badly the last week or two. Acid billets, on the other hand, are freely bought. Continental soft basic billets are offered at as low as £7 delivered Sheffield. There is considerably more doing in open-hearth steel, but crucible and special steels are not making much headway at present. In the market for alloys there is no change in the price of ferro-manganese, and there is very little movement to report this week in this material. Inquiries for tinplates have fallen off, and the aggregate of orders booked during last week was only very moderate. Nevertheless, the market remains quite firm, and although the official minimum selling price still stands at 23s. 6d. per basis box, 24s. 9d. has been freely paid, and most of the makers are holding out for 25s.

Scrap.

The outlook in the scrap metal trade at the moment is far from encouraging, the demand for foundry purposes especially being, if anything, quieter than ever. In Lancashire the present quotations, ranging as they do from 85s. to 92s. 6d. per ton for cast scrap, are quite low enough, and it is clearly not a price which stands in the way of business, but diminished consumption at the foundries. Even the finest lots of broken textile machinery scrap are to be had at 92s. 6d., and that in places where Scotch pig-iron—which used to compare with this class of scrap—costs 115s. per ton. In the Scottish foundry trade districts there is also only a poor demand. First-class machinery cast-iron scrap in handy pieces is quoted at 97s. 6d., with ordinary cast scrap at 5s. per ton less. Iron and steel works metal is about 87s. 6d. to 90s. The position of old cast-iron chairs is rather unusual; fair quantities are on hand, but holders are reluctant to part with them at the figure offered, *i.e.*, 95s. to 96s. per ton.

Metals.

Copper.—The tendency of standard values during the past week has continued rather irregular, though the undercurrent may be still regarded as firm, based upon American reports of a further restriction of output at the mines. Continental demand is now distinctly better than previously reported, and with the recent improvement in the position of the French exchange, France may be expected to considerably extend its buying capacity in this direction. There can be no question that with more settled conditions in Europe the demand for copper will be largely increased, with a corresponding upward tendency in values. Current quotations:—*Cash*: Thursday, £67; Friday, £67 5s.; Monday, £65 12s. 6d.; Tuesday, £65 5s.; Wednesday, £63 17s. 6d. *Three Months*: Thursday, £67 15s.; Friday, £68 2s. 6d.; Monday, £66 7s. 6d.; Tuesday, £66 5s.; Wednesday, £64 17s. 6d.

Tin.—Generally weaker advices from America at the close of last week caused a decided relapse in tin values, and the position, on the whole, remains much weaker both on cash and forward account. Consumption at home and abroad is well maintained, while the statistical position is distinctly sound and buying continues on an extensive scale, both for South Wales and the Continent. On the selling side, daily sales have been made from the Straits at very reasonable prices, while Batavia has been holding for rather higher prices. Current quotations: — *Cash*: Thursday, £284 15s.; Friday, £285; Monday, £283; Tuesday, £263; Wednesday, £263. *Three Months*: Thursday, £284; Friday, £284 10s.; Monday, £285; Tuesday, £263; Wednesday, £263.

Spelter.—The position in regard to this metal has developed some irregularity of late, consumptive demand having been disappointing, which has contributed to a weaker tendency in values. The undertone, however, is firm. America seems to be the only seller, but if a small decrease in production there seems probable, the reason is somewhat obscure. Current quotations:—*Ordinary*: Thursday, £36 1s. 3d.; Friday, £35 18s. 9d.; Monday, £35 12s. 6d.; Tuesday, £33 17s. 6d.; Wednesday, £34 15s.

Lead.—The market for soft foreign pig continues exceptionally active, and the price has advanced considerably since last reported. With the price of lead now ruling well above the price of spelter, it remains to be seen to what extent the former may be substituted by the latter for manufacturing purposes. Current quotations:—*Soft foreign (prompt)*: Thursday, £38; Friday, £37 15s.; Monday, £36 10s.; Tuesday, £34 12s. 6d.; Wednesday, £35 5s.